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April 11, 2007

Mr. Earl Liverman, On-Scene Coordinator
United States Environmental Protection Agency, Region 10
1200 Sixth Avenue, Mail Stop ECL-116
Seattle, Washington 98101

RE: Contract Number EP-S7-06-02, Technical Direction Document (TDD) Number 07-03-0004;
Avery Landing Site Site-Specific Sampling Plan (SSSP)

Dear Mr. Liverman:

Enclosed please find the Avery Landing Site SSSP. This document is to be used in conjunction with the Generic Quality Assurance Project Plan (QAPP), completed under TDD Number 02-02-0003, to meet EPA Quality System requirements. If you have any further questions or comments, please contact me at (206) 624-9537.

Sincerely,

Jeffrey Fowlow
START-3 Project Leader

Enclosures

cc: Steven Hall, START-3 Project Manager, E & E, Seattle, WA

Avery Landing Site Site-Specific Sampling Plan

TDD: 07-03-0004

Ecology and Environment, Inc.

Contract: EP-S7-06-02

April 10, 2007

Revision 1.0

Region 10

START-3

Superfund Technical Assessment and Response Team

START Sample Numbers: 07040101 through 07040200

SITE-SPECIFIC SAMPLING PLAN (SSSP) FOR REMOVAL PROGRAM SITES

Project Name: Avery Landing Site
 Technical Direction Document (TDD) Number: 06-09-0001
 Contract Number: EP-S7-06-02

APPROVALS			
Name	Title	Signature	Date
Earl Liverman	On-Scene Coordinator (OSC)	<i>Earl Liverman</i>	4/10/07
Kathy Parker	Emergency Response Unit (ERU) Quality Assurance Coordinator (QAC)	<i>Kathy Parker</i>	4/10/2007
Steven Hall	START-3 Project Manager	<i>Steven Hall</i>	4/10/2007
Mark Woodke	START-3 Quality Assurance Officer	<i>Mark Woodke</i>	4/10-07

This SSSP is prepared and used in conjunction with the Generic Superfund Technical Assessment and Response Team (START) Quality Assurance Project Plan (QAPP), January 2003, for collecting samples during Removal Program (RP) projects. Refer to the Generic START QAPP for additional details relating to the SSSP.

Additional Personnel and Affiliations involved in the project

U. S. Environmental Protection Agency (EPA) OSC			
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ERU QAC			
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Mike Baxter	940 South Harney Street Seattle, WA 98108	(206) 767-8000	MikeB@tl.laucks-labs.com

Physical Description and Contact Information

Site Name	Avery Landing Site (See Figure 1; Site Vicinity Map)	
Site Location	Address: one mile west of Avery on State Highway 50	
	Avery, Shoshone County, Idaho	
	Latitude: 47° 13' 57" North	Longitude: -115° 43' 40" West
Property size	Acres: 8	
Site Contact	Name: Gary Stevens, Idaho Department of Environmental Quality	Phone Number: (208) 769-1422
Site Owner	Name: Potlatch Inc., U.S. Highway Administration, David Thierault	Phone Number: To be determined
Site Operator	Name: Potlatch Inc.	Phone Number: To be determined
Nearest Residents	Distance: Permanent and seasonal residents live within the site evaluation boundary.	Direction: West
Primary land uses surrounding the site	The site is within one mile of Avery (population 57), which has permanent and seasonal residential, commercial, and recreational uses. Avery is a popular destination for outdoor activities, and has significant logging activity nearby. An elementary school and a junior high school are one mile northwest of the site (See Figure 2; Site Location Map)	

The Data Quality Objective process will be used to determine all sample locations; this process is further described in the Generic START QAPP.

Historical and Background Information

The Avery Landing site is located in Avery, Shoshone County, Idaho (Figure 1). The site is located one mile west of Avery on State Highway 50 (Figure 2). The site is approximately 1,550 feet long and varies between 150 to 300 feet in width.

The St. Joe River is designated a special resource water. Ground water at the site is approximately 8 to 16 feet below ground surface (bgs) and flows towards the river.

The site is a former railroad roundhouse and maintenance yard used by the Chicago, Milwaukee, St. Paul, and Pacific Railroad (CMSPR) from 1909 to approximately 1977. CMSPR site activities included railroad equipment refueling and maintenance, and possibly storage of transformers (CMSPR was the nation's largest electrified railroad). The site was purchased by Potlatch Inc., in 1980. Potlatch is suspected to own most of the contaminated property. Other potential owners for a portion of the property include the U.S. Highway Administration and David Thierault.

Potlatch has been addressing free product petroleum contamination at the site pursuant to an Idaho Department of Environmental Quality (IDEQ) Consent Order since 1994. The recovery system,

which was implemented in 2000, included installation of a containment wall and 27 monitoring and extraction wells to prevent the migration of Light Non-Aqueous Phase Liquids (LNAPL) from the site to the St. Joe River.

As agreed upon in the Consent Order, the focus on remediation and monitoring has been on the free petroleum product. During September 2005, LNAPL was observed seeping from the river bank causing a sheen on the river. It is not yet known why the seepage is occurring (e.g., a tear in the containment wall and/or product flowing around or beneath the wall).

Given the previous use of the property as a railroad maintenance and refueling facility, it is likely that other contaminants besides free petroleum product hydrocarbons may be present on-site. To date, the remediation has been based on limited site delineation with no regard for dissolved-phase petroleum hydrocarbons, other potential contaminants, and the geographic distribution of these contaminants. The fate and transport of other potential constituents and petroleum hydrocarbon phases, and the potential impact to the St. Joe River, is not well-known; thus, without additional information, it is difficult to determine the present condition of the site and the effectiveness of the current containment system.

Given the release and limited scope of previous cleanup actions, IDEQ and EPA believe that there may be dissolved-phase contamination in the on-site groundwater, which may also be discharged to the St. Joe River. Contaminants that may be on site include dissolved-phase hydrocarbons; the volatile organic compounds (VOCs) benzene, toluene, ethylbenzene, and xylenes (BTEX); and the semivolatile organic compounds (SVOCs) polynuclear aromatic hydrocarbons (PAHs). Therefore, EPA has determined that this site poses a potential threat to human health and the environment and will conduct further assessment of the threat as requested by IDEQ.

The following decision areas are present at the site: contaminated soil; groundwater; and the sediments and surface water of the St. Joe River.

The contaminants of concern include dissolved-phase hydrocarbons, BTEX, PAH, polychlorinated biphenyls (PCBs), and metals. There is currently visible sheen migrating into the St. Joe River, which is designated a special resource water. Free phase hydrocarbons were found in on-site monitoring wells in the late 1990s through 2005 (the latest year for which data is available). Dissolved-phase hydrocarbons, lead, and arsenic were found above the MCL in a 1993 groundwater sample.

There are no anticipated sampling constraints. The proposed schedule of project work follows:

Activity	Estimated Start Date	Estimated Completion Date	Comments
SSSP Review/Approval ^a	April 3, 2007	April 10, 2007	
Mobilize to Site	April 16, 2007 through April 23, 2007		
Sample Collection			
Laboratory Sample Receipt			
Laboratory Analysis	April 18, 2007	May 15, 2007	
Data Validation	May 16, 2007	May 23, 2007	
Draft Report	June 15, 2007		
Target Completion Date	June 30, 2007		

^a For emergency response projects, the SSSP may be submitted within 30 days after the response date. For projects involving the EPA Region 10 laboratory, the EPA RSCC must review and approve the SSSP prior to sample collection activities.

Conceptual Site Model

Figure 3 (Site Layout and Historic Maximum Product Thicknesses) shows the site layout which includes the location of free phase hydrocarbon, the existing extraction trench, the containment wall, the test pit locations and the collection well locations. Figure 4 (Proposed Sample Location Map) shows the proposed sampling locations, including six monitoring wells, three soil borings, seven sediment samples, 2 surface water samples, and one domestic well.

Decision Statement

The decisions to be made from this investigation are to:

- Determine whether VOC, SVOCs, target analyte list (TAL) metals, PCBs and diesel-range dissolved-phase hydrocarbons are present on the site;
- Determine whether contamination exceeds the regulatory limits established for this project, including the Idaho Risk Evaluation Manual, July 2004; Idaho Water Quality Standards (Idaho Administrative Procedures Act [IDAPA] 58.01.02); and the Federal Maximum Contaminant Levels (MCLs) for drinking water. The results will also be compared to other state and federal standards and guidelines, including the EPA Region 6 2006 Human Health Medium-Specific Screening Levels (HHMSSL) and the federal Ambient Water Quality Criteria (AWQC) for Freshwater (a table with a summary of applicable regulatory limits is provided in Attachment A, and Attachment B includes the laboratory detection limits); and
- Determine whether contaminated groundwater is impacting the St. Joe River.

Inputs into the Decision

The following information will be provided from project activities:

- Contaminant concentrations in subsurface soil, sediment, surface water, and ground water at source and target locations. This information will be gathered through the project activities described in this SSSP.
- Current and future on-site and off-site land use. The area has a mixture of permanent and seasonal residential, commercial, recreational, and industrial uses, and this is expected to continue in the future.

Sample Collection Information

Applicable sample collection Standard Operating Procedures (SOPs; provided in Attachment C) will be followed, including Field Activity Logbooks, Groundwater Well Sampling, Sediment Sampling, Overburden Monitoring Well/Piezometer Installation, Sample Packaging, Surface Water Sampling, Soil Sampling, VOC-Soil and Sediment Sampling, Borehole Sampling, Borehole Installation, Evaluation of Existing Monitoring Wells, Well Development, Monitoring Well Installation, Geologic Logging, Measuring Water Level and Well Depth, and Sampling Equipment Decontamination.

- **Subsurface Soil, Surface Water, and Groundwater:** Contaminants with moderate or high solubility and/or low sorption properties are expected to have migrated into subsurface soil, surface water, and/or groundwater; therefore the subsurface soil sample collection depth of greater than 6 inches below ground surface (bgs) and/or surface water and groundwater sample collection is appropriate.
- **Sediment:** Contaminants with high sorption properties are expected to have migrated into sediments; therefore, the sample collection depth of less than 6 inches bgs is appropriate.

Decision Areas

The decision areas include:

- The groundwater within the capture zone of the residential domestic well.
- The Avery Landing site, where former railroad operation and maintenance activities were performed.
- The portion of the St. Joe River and its river bank adjacent to the site.

Temporal Study Boundaries

The site was used as a railroad maintenance and refueling facility from 1909 through 1977, and contaminants are suspected to have been released at the site throughout this period. Actual or threatened releases of petroleum products and other hazardous substances from the site may be occurring; thus, the site must be evaluated to determine whether there is an immediate risk to public health or welfare or the environment.

The Decision Rule

The following statements describe the decision rules to apply to this investigation:

- If the concentrations of contaminants in the residential well decision area are greater than the Drinking Water MCL, the area may be targeted for additional characterization or removal.
- If the concentrations of contaminants in the other decision areas are greater than the applicable state and federal regulatory limits and guidelines (summarized in Attachment A), the area may be targeted for additional characterization or removal.
- If the concentrations of contaminants in the decision areas are less than the state and federal regulatory limits and guidelines summarized, and there is no longer been releasing into the St. Joe River, the area may be characterized as not posing an unacceptable risk to human health or the environment and may be dismissed from additional RP activities. The area may be referred to other Federal, State or Local government agencies.

Limits on Decision Error

All analytical testing results will be subjected to data validation. Data are considered valid if the specified limits on precision, accuracy, representativeness, comparability, and completeness are achieved. The results of detected target constituents will be considered in evaluating the need for additional sampling of subsurface soil, surface water, sediments and groundwater.

Design Optimization

Sampling

All samples will be collected following applicable SOPs referenced in the 2003 Ecology and Environment, Inc. (E & E) Generic QAPP for Sampling at Removal Program Sites. The objective of ground water, surface water, sediment, and subsurface soil sampling is to estimate the current and/or localized contaminant concentrations, therefore grab sampling is consistent with the intended use of the data.

Sampling Pattern

- Surface water samples will be collected adjacent to the east and west seep areas, as indicated on Figure 4, to determine potential contaminant sources. An additional surface water sample may also be collected upstream of the site, as a background sample.
- Groundwater samples will be collected from newly-installed monitoring wells and a domestic

well at appropriate depths in the aquifer. The wells will be distributed around the site, as indicated on Figure 4, to determine localized contaminant concentrations.

- Subsurface soil samples will be collected while boring the new monitoring wells and at additional boring locations. The subsoil sampling points will be distributed around the site, as indicated on Figure 4, to determine the localized contaminant concentrations. The soil will be collected from the vadose zone.
- Sediment samples will be collected from various locations upstream of and downstream from the site, as indicated on Figure 4, to determine contaminant sources and migration.

Numbers of Samples

- Approximately seven groundwater samples will be collected, including one from each of the six newly-installed monitoring wells and one from the domestic well. If possible, depending on schedule and budget, additional monitoring wells may be installed at the site. The estimated number of monitoring wells that may be installed at the site range from a minimum of five to as many as nine.
- Approximately nine soil boring samples will be collected. These include six with the monitoring well installations and three additional borings from the site. Depending on schedule and budget, additional soil borings may also be collected. The estimated number of soil borings to be collected at the site range from nine to 15, including those for monitoring well installation.
- Seven sediment samples from along the northern St. Joe River shoreline will be collected.
- As many as three surface water samples from the St. Joe River will be collected. One surface water sample will be collected upstream of the site as a background sample, and two surface water samples will be collected from the same locations as two of the sediment samples, as shown on Figure 4.

Types and Locations of Samples

Samples will be collected from the decision areas. See Figure 4 for the proposed location of each sample. If additional monitoring wells or soil borings are collected, they will be located as directed by the OSC.

Sample Matrix and Target Analytes

Each sample will be analyzed for SVOCs, VOCs, TAL metals, PCBs and diesel-range total petroleum hydrocarbons. Methods will be those referenced in the E & E Generic QAPP for Sampling at Removal Program Sites and as listed below. See Tables 1, 2, 3 and 4 for sample collection and analysis information. The Sample Plan Alteration Form (a blank form is included at the end of this document) will list project discrepancies (if any) that occurred between planned project activities listed in the final SSSP and actual project work.

<p style="text-align: center;">Table 1</p> <p style="text-align: center;">SAMPLE INFORMATION SUMMARY</p> <p style="text-align: center;">AVERY LANDING SITE</p> <p style="text-align: center;">AVERY, IDAHO</p>						
Project Sampling Schedule^a	Parameter/Limits^b	Design Rationale	Sampling Design Assumptions	Sample Selection Procedures	Measurement Classification (Critical/Non Critical)	Nonstandard Method Validation
Subsurface Soil and Sediment	VOCs/MDL PCBs/MDL SVOCs/MDL TAL metals/MDL NWTPH-Dx/25 mg/kg	To determine if contaminants are present in on-site soils or nearby sediments.	Contaminants were released to the soil and sediments.	Samples will be collected from potentially contaminated areas. ^c	Critical	NWTPH-Dx per method.
Groundwater or Surface Water Adjacent to Site	VOCs/MDL PCBs/MDL SVOCs/MDL TAL metals/MDL NWTPH-Dx/0.25 mg/L	To determine if contaminants are present in on- and off-site surface water/ groundwater.	Contaminants were released to the water.	Samples will be collected from potentially contaminated areas. ^c	Critical	NWTPH-Dx per method

^a All samples will be collected during the field event. The listed items are the decision areas.

^b Detection limits will be method/laboratory limits for air, SW-846, and field methods. The MDL and reporting limits for the laboratories and analyzers to be used for this project are included in Attachment B.

^c As indicated from previous investigations at the site and from on-site observations. All locations will be determined by the OSC.

Key:

Critical = Required to achieve project objectives or limits on decision errors.
MDL = Method detection limits.
Noncritical = For informational purposes or needed for background information.
NWTPH-Dx = Northwest Total Petroleum Hydrocarbons Extended Diesel Range.
PCBs = Polychlorinated biphenyls.

RCRA = Resource Conservation and Recovery Act.
START = Superfund technical assessment and response team.
SVOCs = Semivolatile organic compounds.
TAL = Target analyte list.
VOC = Volatile organic compound.

Table 2
SAMPLE ANALYSES SUMMARY
AVERY LANDING SITE
AVERY, IDAHO

Matrix	Location	Analytical Parameters/Method ^a	Sample Preservation	Technical Holding Time ^b	Sample Container(s)
Soil/ Sediment	On- Site and in St. Joe River	TAL metals/EPA SW-846 Methods 6010C/6020A/7000 Series or CLPAS ILM05.3	Cool to 4 °C ± 2 °C	180 days from collection (28 days for mercury)	One 8-oz wide-mouth glass jar with Teflon-lined lid
		VOCs/EPA SW-846 Methods 5035/8260B or CLPAS SOM01.1	Cool to 4 °C ± 2 °C	14 days from collection to analysis (samples must be to lab in < 48 hours)	Three 5-gram EnCore™ samplers plus one 40-mL VOA vial (for % moisture)
		SVOCs/EPA SW-846 Method 8270D or CLPAS SOM01.1	Cool to 4 °C ± 2 °C	Extract within 14 days of collection; analyze within 40 days of extraction	One 8-oz wide-mouth glass jar with Teflon-lined lid
		PCBs/ EPA SW-846 Method 8082A or CLPAS SOM01.1	Cool to 4 °C ± 2 °C	Extract within 14 days of collection; analyze within 40 days of extraction	One 8-oz wide-mouth glass jar with Teflon-lined lid
		Diesel-Range Petroleum Hydrocarbons/Ecology Method NWTPH-Dx	Cool to 4 °C ± 2 °C	Extract within 14 days of collection; analyze within 40 days of extraction	One 4-oz wide-mouth glass jar with Teflon-lined lid
Water	Drinking Water Wells and Monitoring Wells	TAL metals/EPA SW-846 Methods 6010C/6020A/7000 Series or CLPAS ILM05.3	Cool to 4 °C ± 2 °C HNO ₃ to pH ≤ 2	180 days from collection (28 days for mercury)	One 1-Liter Polyethylene bottle with Teflon-lined lid
		VOCs/EPA SW-846 Method 8260B or CLPAS SOM01.1	Cool to 4 °C ± 2 °C HCl to pH ≤ 2	14 days from collection to analysis	Two 40-mL glass vials with Teflon-lined septa
		SVOCs/EPA SW-846 Method 8270D or CLPAS SOM01.1	Cool to 4 °C ± 2 °C	Extract within 7 days of collection; analyze within 40 days of extraction	Two 32-oz amber glass jars with Teflon-lined lid
		PCBs/ EPA SW-846 Method 8082A or CLPAS SOM01.1	Cool to 4 °C ± 2 °C	Extract within 7 days of collection; analyze within 40 days of extraction	Two 32-oz amber glass jars with Teflon-lined lid
		Diesel-Range Petroleum Hydrocarbons/Ecology Method NWTPH-Dx	Cool to 4 °C ± 2 °C HCl to pH ≤ 2	Extract within 14 days of collection; analyze within 40 days of extraction	Two 32-oz amber glass jars with Teflon-lined lid

^a In general, preservation, holding times, and containers for soil and water TAL metals and VOCs are those listed under the associated analytical laboratory method.

^b Technical holding times have been established only for water matrices. Water and/or recommended holding times were applied to air, sediment, soil, and product samples where applicable.

Key:

°C	= Degrees Celsius.	mL	= Milliliter.	START	= Superfund technical assessment and response team.
CLPAS	= Contract Laboratory Program Analytical	na	= Not applicable.	SVOCs	= Semivolatile organic compounds.
EPA	= United States Environmental Protection Agency.	NWTPH-Dx	= Northwest Total Petroleum Hydrocarbons	TAL	= Target analyte list.
HCl	= Hydrochloric acid.	oz	= Ounce.	VOCs	= Volatile organic compounds
HNO ₃	= Nitric acid.				

The laboratory's DQOs for completeness and the field team's ability to meet the DQO for representativeness are set at 90%. Precision and accuracy requirements are outlined in Table 3.

Table 3
QA/QC ANALYTICAL SUMMARY and FIXED LABORATORY ANALYTICAL METHODS
AVERY LANDING SITE
AVERY, IDAHO

Laboratory	Matrix	Parameters/Method	Method Description/ Detection Limits	Total Field Samples ^a / Containers	QA/QC Sample Summary Additional Analyses / Additional Containers				Total Field and QA/QC Analyses/ Containers ^e	Precision and Accuracy
					Organic MS&MSD ^b	Inorganic MS&Dup ^b	Rinsate Blanks ^c	Trip Blanks ^d		
Laucks	Soil / Sediment	TAL metals/EPA SW-846 Methods 6010C/6020A/7000 Series or CLPAS ILM05.3	AA & ICP/MDL	16/16	NA	1/0	See below	NA	17/16	± 35% 75% - 125%
STL		PCBs/EPA SW-846 Methods 8081B/8082A or CLPAS SOM01.1	GCS & ECD/MDL	16/16	1/0	NA	See below	NA	17/16	± 35% 60% - 140%
Laucks		VOCs/EPA SW-846 Method 5035/8260B or CLPAS SOM01.1	GCS & MD/MDL	16/48	1/8	NA	See below	See below	17/56	± 35% 60% - 140%
STL		SVOCs/EPA SW-846 Method 8270D or CLPAS SOM01.1	GCS & MD/MDL	16/16	1/0	NA	See below	NA	17/16	± 35% 60% - 140%
Laucks		Diesel-range petroleum hydrocarbons/ NWTPH-Dx	GCS & FID/25 mg/kg	16/16	1/0	NA	See below	NA	17/16	± 35% 60% - 140%
Laucks	Water	TAL metals/EPA SW-846 Methods 6010C/6020A/7000 Series or CLPAS ILM05.3	AA & ICP/MDL	10/10	NA	1/1	See below	NA	10/10	± 35% 75% - 125%
STL		PCBs/EPA SW-846 Methods 8081B/8082A or CLPAS SOM01.1	GCS & ECD/MDL	10/20	1 / 4	NA	See below	NA	10/22	SOM01.1/ SOM01.1
Laucks		VOCs/EPA SW-846 Method 8260B or CLPAS SOM01.1	GCS & MD/MDL	10/20	1 / 4	NA	See below	See below	10/22	SOM01.1/ SOM01.1
STL		SVOCs/EPA SW-846 Method 8270D or CLPAS SOM01.1	GCS & MD/MDL	10/20	1 / 4	NA	See below	NA	10/22	SOM01.1/ SOM01.1
Laucks		SVOC Petroleum Products/ NWTPH-Dx	GCS & FID/0.25 mg/L	10/20	1 / 4	NA	See below	NA	10/22	± 35% 60% - 140%

<p align="center">Table 3</p> <p align="center">QA/QC ANALYTICAL SUMMARY and FIXED LABORATORY ANALYTICAL METHODS</p> <p align="center">AVERY LANDING SITE</p> <p align="center">AVERY, IDAHO</p>										
Laboratory	Matrix	Parameters/Method	Method Description/ Detection Limits	Total Field Samples ^a / Containers	QA/QC Sample Summary Additional Analyses / Additional Containers				Total Field and QA/QC Analyses/ Containers ^e	Precision and Accuracy
					Organic MS&MSD ^b	Inorganic MS&Dup ^b	Rinsate Blanks ^c	Trip Blanks ^d		
Laucks	Rinsate Blanks (Water)	TAL metals/EPA SW-846 Methods 6010C/6020A/7000 Series or CLPAS ILM05.3	AA & ICP/MDL	NA	NA	NA	1 / 1	NA	1 / 1	NA
STL		PCBs/EPA SW-846 Method 8082A or CLPAS SOM01.1	GCS & ECD/MDL	NA	NA	NA	1 / 2	NA	1 / 2	NA
Laucks		VOCs/EPA SW-846 Method 8260B or CLPAS SOM01.1	GCS & MD/MDL	NA	NA	NA	1 / 2	NA	1 / 2	NA
STL		SVOCs/EPA SW-846 Method 8270D or CLPAS SOM01.1	GCS & MD/MDL	NA	NA	NA	1 / 2	NA	1 / 2	NA
Laucks		SVOC Petroleum Products/ NWTPH-Dx	GCS & FID/ 0.25 mg/L	NA	NA	NA	1 / 2	NA	1 / 2	NA
Laucks	Trip Blanks (Water)	VOCs/EPA SW-846 Method 8260B or CLPAS SOM01.1	GCS & MD/MDL	NA	NA	NA	NA	2 / 4	2 / 4	NA

^a Total number of field samples is estimated.

^b No extra volume is required for soil/sediment or product samples; for water samples, triple volume is required for organic analyses, and double volume is required for inorganic analyses. Sample numbers are based on 1 matrix spike/matrix spike duplicate (MS/MSD) per 20 samples per matrix.

^c The total number of rinsate samples could vary depending on the total number of samples collected. The sample numbers are based on one rinsate per 20 samples per nondedicated sampling device. Note that rinsate blanks consist of water aliquots for both soil and water field samples.

^d The total number of trip blanks could vary depending on the total number of sample shipments. This number is based on the estimated number of shipping containers. Note that trip blanks consist of water aliquots for both soil and water field samples.

^e Total analyses and containers includes both field and QA/QC aliquots to be submitted for fixed laboratory analysis. Note that trip blanks and rinsate blanks consist of water aliquots for both soil and water field samples.

Key:

AA = Atomic absorption furnace technique
CLPAS = Contract laboratory program analytical service.
CRQL = Contract required quantitation limit.
ECD = Electron capture detection.
EPA = Environmental Protection Agency.
FID = Flame Ionization Detector.



GCS = Gas chromatographic separation.
ICP = Inductively coupled plasma.
MD = Mass spectrometric detection.
MDL = Method detection limit.
MS/MSD = Matrix spike/matrix spike duplicate.
NA = Not applicable.

NWTPH-Dx = Northwest Total Petroleum Hydrocarbons Extended

QA = Quality assurance
QC = Quality control.
START = Superfund technical assessment and response team.
SVOCs = Semivolatile organic compounds.
TAL = Target analyte list.
VOCs = Volatile organic compounds.

Table 4 SAMPLE CODING AVERY LANDING SITE AVERY, IDAHO		
Digits	Descriptions	Code Example
1,2	Decision Area	DW (Domestic Well) RS (Rinsate) MW (Monitoring Well) SJ (St. Joe River) TB (Trip Blank)
3,4	Consecutive Sample Number	01 (First Sample of Decision Area)
5,6	Matrix Code	GW (Groundwater) PR (Product) SD (Sediment) SS (Soil) SW (Surface Water) QC (Quality Control) WT (Water)
7,8	Consecutive Sample Number	01 (First sample of Matrix Code)



 <p>ecology and environment, inc. International Specialists in the Environment Seattle, Washington</p>	AVERY LANDING SITE Avery, Idaho		Figure 1 SITE VICINITY MAP		
	 <p>Approximate Scale in Miles</p>		Date: 10/6/06	Drawn by: AES	10:START-3\06090001\fig 1

Source: Maptech, Inc. 2001.



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 Seattle, Washington

AVERY LANDING SITE
 Avery, Idaho

0 1000 2000
 Approximate Scale in Feet

Figure 2
SITE LOCATION MAP

Date:
 10/6/06

Drawn by:
 AES

10:START-3\06090001\fig 2

Source: Farallon Consulting, March 2006.

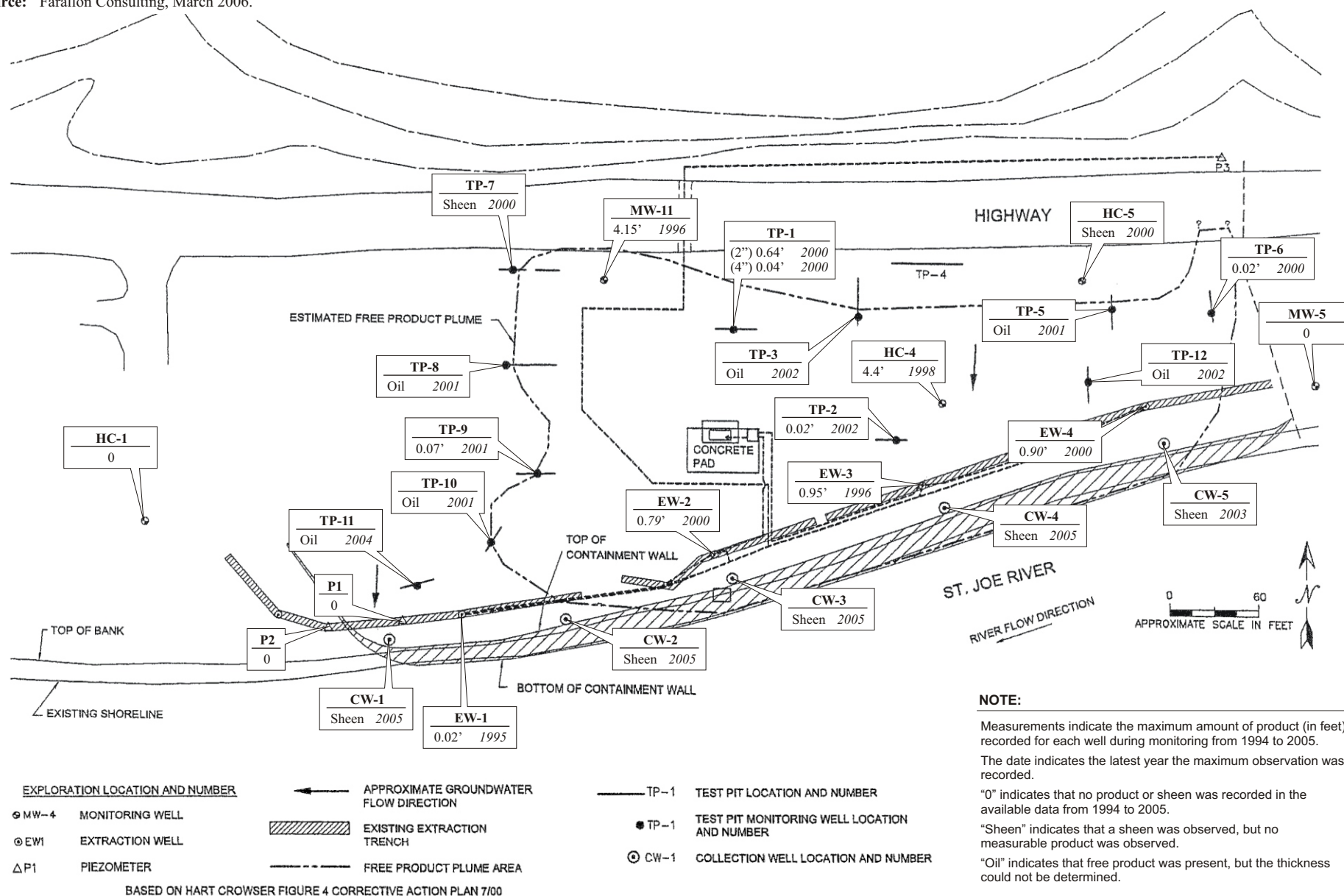


Figure 3
SITE LAYOUT AND HISTORIC
MAXIMUM PRODUCT THICKNESSES

Date:
3/29/07

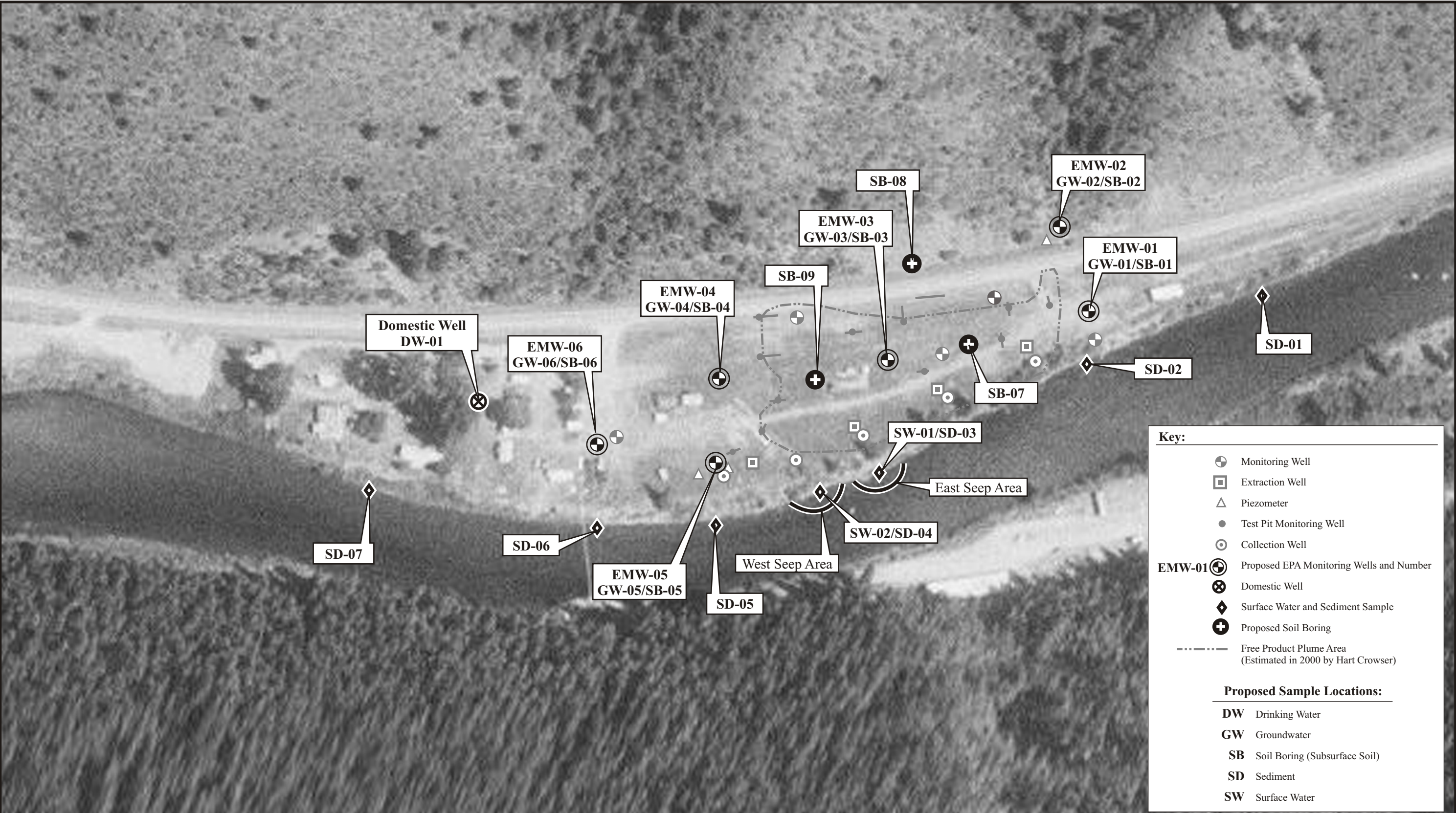
Drawn by:
AES

10:START-3\06090001\fig 3



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International Specialists in the Environment
Seattle, Washington

AVERY LANDING SITE
Avery, Idaho



Sample Plan Alteration Form

Project: Avery Landing Site

TDD Number: 07-03-0004

Changes from Final SSSP (include rationale, decision area, matrices, parameters, equipment, personnel, etc.):

APPROVALS			
Name	Title	Signature	Date
Earl Liverman	On Scene Coordinator		
Kathy Parker	ERU Quality Assurance Coordinator		
Steven Hall	START-3 Project Manager		
Mark Woodke	START-3 Quality Assurance Officer		

Attachment A
Summary of Applicable Regulatory Limits

Table 1. Applicable or Relevant and Appropriate Requirements for Soil, Groundwater, and Surface Water

Class	Compound	Soil (mg/kg)			Groundwater (mg/L)				Surface Water (ug/L)	
		ID REM - Residential (9)	Region 6 - Residential (10)	Region 6 - Industrial Outdoor Worker (10)	ID MCL (1)	Federal MCL (3)	ID REM (5)	Region 6 - Tap Water (10)	ID REM (6)	Federal AWQC (7)
Metal	Aluminum		7.62E+04	1.00E+05	0.2 (2)	0.05 - 0.2 (4)		3.65E+01		
Metal	Antimony	4.77E+00	3.10E+01	4.50E+02	6.00E-03	6.00E-03	6.00E-03	1.50E-02	1.40E+01	50 (proposed)
Metal	Arsenic	3.91E-01	3.90E-01	1.80E+00	5.00E-02	1.00E-02	1.00E-02	4.50E-05	5.00E+01	1.50E+02
Metal	Barium	8.96E+02	1.60E+04	1.00E+05	2.00E+00	2.00E+00	2.00E+00	7.30E+00		4.00E+00
Metal	Beryllium	1.63E+00	1.50E+02	2.20E+03	4.00E-03	4.00E-03	4.00E-03	7.30E-02		5.30E+00
Metal	Cadmium	1.35E+00	3.90E+01	5.60E+02	5.00E-03	5.00E-03	5.00E-03	1.80E-02	Calc.	0.25 H
Metal	Chromium		2.10E+02	5.00E+02	1.00E-01	1.00E-01	1.00E-01		Calc.	
Metal	Chromium (III)	2.13E+03	1.00E+05	1.00E+05			1.00E-01	5.50E+01	Calc.	74 H
Metal	Chromium (VI)	7.90E+00	3.00E+01	7.10E+01			3.13E-02	1.10E-01	1.00E+01	1.10E+01
Metal	Copper	9.21E+02	2.90E+03	4.20E+04	1.30E+00	1.30E+00	1.30E+00	1.40E+00	Calc.	9 H
Metal	Iron	5.76E+00	5.48E+04	1.00E+05	0.3 (2)	0.3 (4)	3.13E+00	2.56E+01		1.00E+03
Metal	Lead	4.96E+01	4.00E+02	8.00E+02	1.50E-02	1.50E-02	1.50E-02	1.50E-02	Calc.	2.5 H
Metal	Manganese	2.23E+02	3.20E+03	4.70E+04	0.05 (2)	0.05 (4)	2.50E-01	1.70E+00		1.20E+02
Metal	Mercury	5.09E-03	2.30E+01	3.40E+02	2.00E-03	2.00E-03	2.00E-03	1.10E-02	1.20E-02	7.70E-01
Metal	Nickel	5.91E+01	1.60E+03	2.30E+04			2.09E-01	7.30E-01	Calc.	52 H
Metal	Selenium	2.03E+00	3.90E+02	5.70E+03	5.00E-02	5.00E-02	5.00E-02	1.80E-01	5.00E+00	5.00E+00
Metal	Silver	1.89E-01	3.90E+02	5.70E+03	0.1 (2)	0.1 (4)	5.21E-02	1.80E-01	Calc.	1.6 H
Metal	Thallium	1.55E+00	5.48E+00	7.95E+01	2.00E-03	2.00E-03	2.00E-03	2.56E-03	1.70E+00	4.00E+01
Metal	Zinc	8.86E+02	2.30E+04	1.00E+05	5 (2)	5 (4)	3.13E+00	1.10E+01	Calc.	120 H
PCBs	Aroclor 1016	2.33E+00	3.93E+00	2.36E+01			7.30E-04	9.60E-04		
PCBs	Aroclor 1221	2.94E-03	2.22E-01	8.26E-01			2.79E-05	3.36E-05		
PCBs	Aroclor 1242	3.18E-03	2.22E-01	8.26E-01			2.79E-05	3.36E-05		
PCBs	Aroclor 1248	1.37E-01	2.22E-01	8.26E-01			2.79E-05	3.36E-05		
PCBs	Aroclor 1254	7.40E-01	2.22E-01	8.26E-01			2.09E-04	3.36E-05		
PCBs	Aroclor 1260	1.47E-01	2.22E-01	8.26E-01			2.79E-05	3.36E-05		
PCBs	Polychlorinated biphenyls (PCBs)		2.20E-01	8.30E-01	5.00E-04	5.00E-04		3.40E-05	1.70E-04	1.40E-02
SVOC	1,3,5-Trimethylbenzene	1.45E-01	2.13E+01	7.76E+01			5.21E-01	1.23E-02		
SVOC	2-Methylnaphthalene	3.31E+00					4.17E-02			
SVOC	4-Chloroaniline	1.26E-01	2.44E+02	2.74E+03			4.17E-02	1.46E-01		5.00E+01
SVOC	4-Nitroaniline	2.99E-03					1.47E-03			
SVOC	Acenaphthene	5.23E+01	3.68E+03	3.25E+04			6.26E-01	3.65E-01		5.20E+02
SVOC	Acenaphthylene	7.80E+01					6.26E-01			
SVOC	Aldrin	2.11E-02	2.86E-02	1.13E-01			3.29E-06	3.95E-06	1.30E-04	1.50E+00
SVOC	Alpha-BHC	2.10E-04	9.00E-02	4.00E-01			8.87E-06	1.10E-05	3.90E-03	
SVOC	Aniline	1.96E-02	8.53E+01	3.36E+02			9.80E-03	1.18E-02		
SVOC	Anthracene	1.04E+03	2.19E+04	1.00E+05			3.13E+00	1.83E+00	9.60E+03	0.73 (8)
SVOC	Benzo(a)anthracene	4.22E-01	1.50E-01	2.30E+00			7.65E-05	2.90E-05	2.80E-03	
SVOC	Benzo(a)pyrene	4.22E-02	1.50E-02	2.30E-01			2.00E-04	2.90E-06	2.80E-03	0.014 (8)
SVOC	Benzo(a)pyrene (PAH)				2.00E-04	2.00E-04				
SVOC	Benzo(b)fluoranthene	4.22E-01	1.50E-01	2.30E+00			7.65E-05	1.50E-04	2.80E-03	
SVOC	Benzo(g,h,i)perylene	1.18E+03					3.13E-01	2.90E-05		
SVOC	Benzo(k)fluoranthene	4.22E+00	1.50E+00	2.30E+01			7.65E-04	1.50E-03	2.80E-03	
SVOC	Benzoic acid	7.71E+01	1.00E+05	1.00E+05			4.17E+01	1.46E+02		42 (8)

Class	Compound	Soil (mg/kg)			Groundwater (mg/L)				Surface Water (ug/L)	
		ID REM - Residential (9)	Region 6 - Residential (10)	Region 6 - Industrial Outdoor Worker (10)	ID MCL (1)	Federal MCL (3)	ID REM (5)	Region 6 - Tap Water (10)	ID REM (6)	Federal AWQC (7)
SVOC	Beta-BHC	7.51E-04	3.20E-01	1.40E+00			3.10E-05	3.70E-05	1.40E-02	1.00E+02
SVOC	Bis(2-chloroethyl)ether	1.08E-04	2.11E-01	6.16E-01			5.08E-05	6.02E-05	3.10E-02	
SVOC	Bis(2-ethylhexyl)phthalate	1.18E+01	3.50E+01	1.40E+02	6.00E-03	6.00E-03	6.00E-03	4.80E-03	1.80E+00	3.60E+02
SVOC	Butyl Benzyl Phthalate	5.11E+02	2.40E+02	2.40E+02			2.09E+00	7.30E+00		3.00E+00
SVOC	Carbofuran	9.42E-02	3.06E+02	3.42E+03	4.00E-02	4.00E-02	4.00E-02	1.83E-01		
SVOC	Chlordane	1.53E+00	1.62E+00	7.19E+00	2.00E-03	2.00E-03	2.00E-03	1.92E-04	5.70E-04	2.15E-03
SVOC	Chrysene	3.34E+01	1.48E+01	2.34E+02			7.65E-03	2.95E-03	2.80E-03	0.027 (8)
SVOC	DDD	2.44E+00	2.44E+00	1.11E+01			2.33E-04	2.80E-04	8.30E-04	0.011 (8)
SVOC	DDE	1.72E+00	1.72E+00	7.81E+00			1.64E-04	1.98E-04	5.90E-04	1.05E+03
SVOC	DDT	4.03E-01	1.72E+00	7.81E+00			1.64E-04	1.98E-04	5.90E-04	5.00E-04
SVOC	Dibenzo(a,h)anthracene	4.22E-02	1.50E-02	2.30E-01			7.65E-06	2.90E-06	2.80E-03	
SVOC	Dibenzofuran	6.10E+00	1.45E+02	1.74E+03			4.17E-02	1.22E-02		0.0037 (8)
SVOC	Dieldrin	1.33E-03	3.04E-02	1.20E-01			3.49E-06	4.20E-06	1.40E-04	5.60E-02
SVOC	Diethylphthalate	2.75E+01	4.90E+04	1.00E+05			8.34E+00	2.90E+01	2.30E+04	3.00E+00
SVOC	Dimethylphthalate	2.71E+02	1.00E+05	1.00E+05			1.04E+02	3.70E+02	3.13E+05	3.00E+00
SVOC	Di-n-butyl phthalate	3.10E+01					1.04E+00		2.70E+03	3.00E+00
SVOC	Di-n-octyl phthalate	1.83E+03					4.17E-01			3.00E+00
SVOC	Dinoseb	1.63E-01	6.11E+01	6.84E+02	7.00E-03	7.00E-03	7.00E-03	3.65E-02		
SVOC	Endosulfan	2.49E+00	3.67E+02	4.10E+03			6.26E-02	2.19E-01	5.60E-02	2.80E-02
SVOC	Endrin	3.35E-01	1.83E+01	2.05E+02	2.00E-03	2.00E-03	2.00E-03	1.10E-02	2.30E-03	3.60E-02
SVOC	Fluoranthene	3.64E+02	2.29E+03	2.44E+04			4.17E-01	1.46E+00	3.00E+02	3.98E+03
SVOC	Fluorene	5.48E+01	2.64E+03	2.62E+04			4.17E-01	2.43E-01	1.30E+03	3.9 (8)
SVOC	Gamma-BHC (Lindane)	8.96E-04	4.40E-01	1.90E+00	2.00E-04	2.00E-04	4.30E-05	5.20E-05	1.90E-02	8.00E-02
SVOC	Heptachlor	1.06E-03	1.08E-01	4.26E-01	4.00E-04	4.00E-04	4.00E-04	1.49E-05	2.10E-04	1.90E-03
SVOC	Heptachlor epoxide	2.61E-02	5.34E-02	2.10E-01	2.00E-04	2.00E-04	2.00E-04	7.39E-06	1.00E-04	1.90E-03
SVOC	Hexachlorobenzene	4.27E-02	3.04E-01	1.20E+00	1.00E-03	1.00E-03	1.00E-03	4.20E-05	7.50E-04	3.68E+00
SVOC	Hexachlorocyclopentadiene	1.16E-02	3.65E+02	4.07E+03	5.00E-02	5.00E-02	5.00E-02	2.19E-01	2.40E+02	5.20E+00
SVOC	Indeno(1,2,3-cd)pyrene	4.22E-01	1.50E-01	7.80E+00			7.65E-05	2.90E-05	2.80E-03	
SVOC	Methoxychlor	5.52E+01	3.06E+02	3.42E+03	4.00E-02	4.00E-02	4.00E-02	1.83E-01		3.00E-02
SVOC	Naphthalene	1.14E+00	1.25E+02	2.09E+02			2.09E-01	6.20E-03		6.20E+02
SVOC	N-Nitrosodiphenylamine	2.09E-06	9.93E+01	3.91E+02			1.14E-02	1.37E-02	5.00E+00	
SVOC	Pentachlorophenol	9.07E-03	2.98E+00	1.00E+01	1.00E-03	1.00E-03	1.00E-03	5.60E-04	2.70E-01	1.50E+01
SVOC	Phenanthrene	7.90E+01					3.13E-01			6.3 (proposed)
SVOC	Phenol	7.36E+00	1.83E+04	1.00E+05			3.13E+00	1.10E+01		2.56E+03
SVOC	Pyrene	3.59E+02	2.31E+03	3.20E+04			3.13E-01	1.83E-01	9.60E+02	
SVOC	Toxaphene	3.26E-01	4.42E-01	1.74E+00	3.00E-03	3.00E-03	3.00E-03	6.11E-05	2.00E-04	2.00E-04
VOC	1,1,1,2-Tetrachloroethane	4.09E-02	3.01E+00	7.59E+00			2.15E-03	2.55E-03		
VOC	1,1,1-Trichloroethane	2.00E+00	1.39E+03	1.39E+03	2.00E-01	2.00E-01	2.00E-01	8.36E-01		1.10E+01
VOC	1,1,2,2-Tetrachloroethane	9.15E-04	3.84E-01	9.70E-01			2.79E-04	3.31E-04	1.70E-01	2.40E+03
VOC	1,1,2-Trichloroethane	1.41E-02	8.44E-01	2.08E+00	5.00E-03	5.00E-03	5.00E-03	1.16E-03	6.00E-01	9.40E+03
VOC	1,1-Dichloroethane	3.48E+00	8.46E+02	2.33E+03			1.04E+00	1.22E+00		
VOC	1,1-Dichloroethene	3.88E-02	2.80E+02	4.70E+02	7.00E-03	7.00E-03	7.00E-03	3.40E-01		
VOC	1,2,4-Trichlorobenzene	6.92E-01	1.43E+02	2.65E+02	7.00E-02	7.00E-02	7.00E-02	8.16E-03	9.60E+02	5.00E+01
VOC	1,2-Dibromo-3-chloropropane	9.75E-04	2.63E-03	1.96E-02			2.00E-04	1.96E-05		
VOC	1,2-Dichlorobenzene	5.25E+00	2.79E+02	3.73E+02			6.00E-01	4.93E-02	2.70E+03	

Class	Compound	Soil (mg/kg)			Groundwater (mg/L)				Surface Water (ug/L)	
		ID REM - Residential (9)	Region 6 - Residential (10)	Region 6 - Industrial Outdoor Worker (10)	ID MCL (1)	Federal MCL (3)	ID REM (5)	Region 6 - Tap Water (10)	ID REM (6)	Federal AWQC (7)
VOC	1,2-Dichloroethane	7.67E-03	3.50E-01	8.40E-01	5.00E-03	5.00E-03	5.00E-03	7.30E-04	3.80E-01	2.00E+04
VOC	1,2-Dichloroethene (cis)	1.93E-01	4.30E+01	1.60E+02	7.00E-02	7.00E-02	7.00E-02	6.10E-02		1.16E+04
VOC	1,2-Dichloroethene (trans)	3.65E-01	1.20E+02	2.00E+02	1.00E-01	1.00E-01	5.59E-04	1.10E-01		1.16E+04
VOC	1,2-Dichloropropane	8.90E-03	3.51E-01	8.47E-01	5.00E-03	5.00E-03	5.00E-03	9.75E-04		
VOC	1,3-Dichlorobenzene	2.29E-01	6.85E+01	1.44E+02			9.39E-03	1.45E-02	4.00E+02	
VOC	1,3-Dichloropropene (cis)	2.45E-03	7.00E-01	1.70E+00			5.59E-04	6.70E-04		
VOC	1,3-Dichloropropene (trans)	2.45E-03	7.00E-01	1.70E+00				6.70E-04		
VOC	1,4-Dichlorobenzene	7.55E-02	3.20E+00	8.07E+00			7.50E-02	2.76E-03	4.00E+02	7.63E+02
VOC	2,4-Dichlorophenol	9.78E-02	1.83E+02	2.05E+03			3.13E-02	1.10E-01		3.65E+02
VOC	2-Chlorophenol	3.65E-01	6.35E+01	2.62E+02			5.21E-02	3.04E-02		4.38E+03
VOC	Acetone	1.74E+01	1.42E+04	6.05E+04			9.39E+00	5.48E+00		
VOC	Acrolein	9.65E-03	1.03E-01	3.75E-01			5.21E-03	4.16E-05	3.20E+02	
VOC	Acrylonitrile	1.94E-04	2.10E-01	5.46E-01			1.03E-04	1.24E-04	5.90E-02	
VOC	Benzene	1.78E-02	6.56E-01	1.60E+00	5.00E-03	5.00E-03	5.00E-03	1.21E-03	1.20E+00	1.30E+02
VOC	Bromodichloromethane	2.68E-03	1.03E+00	2.56E+00			9.01E-04	1.07E-03		
VOC	Bromoform	2.92E-02	6.20E+01	2.40E+02	1.00E-01		7.07E-03	8.50E-03	4.30E+00	
VOC	Bromomethane	5.01E-02	3.90E+00	1.46E+01			1.46E-02	8.66E-03		
VOC	Carbon Disulfide	5.97E+00	7.21E+02	7.21E+02			1.04E+00	1.04E+00		
VOC	Carbon Tetrachloride	1.14E-02	2.40E-01	5.82E-01	5.00E-03	5.00E-03	5.00E-03	5.14E-04	2.50E-01	9.80E+00
VOC	Chlorobenzene	6.18E-01	2.73E+02	5.03E+02		1.00E-01	1.00E-01	9.13E-02	6.80E+02	5.00E+01
VOC	Chloroethane	5.33E-02					1.93E-02			
VOC	Chloroform	5.64E-03	2.45E-01	5.80E-01	2.00E-03		1.80E-03	1.67E-04	5.70E+00	1.24E+03
VOC	Chloromethane	2.31E-02	1.26E+00	2.98E+00			4.30E-03	2.13E-03		
VOC	Dichlorodifluoromethane	2.96E+00	9.41E+01	3.40E+02			2.09E+00	3.95E-01		1.10E+04
VOC	Ethylbenzene	1.02E+01	2.34E+02	2.34E+02	7.00E-01	7.00E-01	7.00E-01	1.34E+00	3.10E+03	7.30E+00
VOC	Hexachlorobutadiene	3.78E-02	6.24E+00	2.46E+01			1.00E-03	8.62E-04	4.40E-01	9.30E+00
VOC	Hexachloroethane	1.38E-01	3.47E+01	1.37E+02			3.99E-03	4.80E-03	1.90E+00	5.40E+02
VOC	Isopropylbenzene (cumene)	3.46E+00	3.70E+02	5.80E+02			1.04E+00	6.60E-01		
VOC	Methyl Ethyl Ketone (2-Butanone)	1.18E+01	3.20E+04	3.20E+04			6.26E+00	7.10E+00		
VOC	Methylene Chloride	1.69E-02	8.90E+00	2.23E+01			7.45E-03	8.94E-03	4.70E+00	2.20E+03
VOC	sec-Butylbenzene	1.17E+00	1.12E+02	2.23E+02			1.04E-01	6.08E-02		
VOC	Styrene	1.83E+00	1.73E+03	1.73E+03	1.00E-01	1.00E-01	1.00E-01	1.64E+00		
VOC	Tetrachloroethylene	2.88E-02	5.50E-01	1.70E+00	5.00E-03	5.00E-03	5.00E-03	1.20E-04		8.40E+02
VOC	Toluene	4.89E+00	5.21E+02	5.21E+02	1.00E+00	1.00E+00	1.00E+00	2.28E+00	6.80E+03	9.80E+00
VOC	Trichloroethene	2.88E-03	4.30E-02	1.00E-01	5.00E-03	5.00E-03	5.00E-03	1.70E-04	2.70E+00	2.19E+04
VOC	Trichlorofluoromethane	1.04E+01	3.87E+02	1.42E+03			3.13E+00	1.29E+00		
VOC	Vinyl Chloride	9.63E-03	4.30E-02	8.63E-01	2.00E-03	2.00E-03	2.00E-03	1.50E-05	2.00E+00	1.16E+04
VOC	Xylene (total)	1.67E+00	2.10E+02	2.10E+02	1.00E+01	1.00E+01	1.00E+01	2.00E-01		1.30E+01

Notes:

- 1 - Ground Water Quality Standards IDAPA 58.01.11, Section 200, Table II - Primary Constituent Standard (2006)
- 2 - Ground Water Quality Standards IDAPA 58.01.11, Section 200, Table III - Secondary Constituent Standard (2006)
- 3 - National Primary Drinking Water Standards (June, 2003)
- 4 - National Secondary Drinking Water Standards (June, 2003)
- 5 - Idaho Risk Evaluation Manual, Table 3-3 (July 2004)
- 6 - Idaho Risk Evaluation Manual, Table 3-5 (July 2004). Lowest value for fresh water and human health.
- 7 - Ambient Water Quality Criteria for Freshwater. Lowest of CMC ("acute") and CCC ("chronic").
- 8 - Ambient Water Quality Criteria for Freshwater, Tier II Value. Lowest of CMC ("acute") and CCC ("chronic").
- 9 - Initial Default Target Levels, April 2004.
- 10 - Region 6 Human Health Medium-Specific Screening Levels, February 21, 2007.

Calc = Value calculated based on hardness.

H = Hardness-dependent value with 400 mg/L as maximum calcium carbonate; value entered is for 100 mg/L calcium carbonate.

Attachment B
Laboratory Detection Limits

STL-Seattle, Inc. Detection Limits

Location Code: 580

STL Seattle

Limit Group Description: gcs 8082_solid_RL/MDL

Type: MDL

Created: 5/18/2006 7:06:00 PM

Active: 5/18/2006 7:11:20 PM

Initial Prep: 10

Unit: g

Final Prep: 10

Unit: mL

Analyte Description	Limit	Units
PCB-1016	0.0058	mg/Kg
PCB-1221	0.0058	mg/Kg
PCB-1248	0.0058	mg/Kg
PCB-1232	0.0058	mg/Kg
PCB-1254	0.0015	mg/Kg
PCB-1242	0.0058	mg/Kg
PCB-1260	0.0015	mg/Kg

Type: RL

Created: 7/15/2005 3:21:00 PM

Active: 6/24/2004 3:23:18 PM

Initial Prep: 10

Unit: g

Final Prep: 10

Unit: mL

Analyte Description	Limit	Units
PCB-1016	0.01	mg/Kg
PCB-1221	0.01	mg/Kg
PCB-1248	0.01	mg/Kg
PCB-1232	0.01	mg/Kg
PCB-1254	0.01	mg/Kg
PCB-1242	0.01	mg/Kg
PCB-1260	0.01	mg/Kg

Location Code:

580

STL Seattle

Limit Group Description:

gcs 8082 & 608_Waters_RL/MDL

Type:

MDL

Created:

5/18/2006 6:56:00 PM

Active:

5/18/2006 7:01:19 PM

Initial Prep:

1000

Unit:

mL

Final Prep:

10

Unit:

mL

Analyte Description	Limit	Units
PCB-1016	0.08	ug/L
PCB-1221	0.08	ug/L
PCB-1248	0.08	ug/L
PCB-1232	0.08	ug/L
PCB-1254	0.05	ug/L
PCB-1242	0.08	ug/L
PCB-1260	0.05	ug/L

Type:

RL

Created:

5/22/2006 1:02:00 PM

Active:

5/18/2006 1:03:06 PM

Initial Prep:

1000

Unit:

mL

Final Prep:

10

Unit:

mL

Analyte Description	Limit	Units
PCB-1016	0.5	ug/L
PCB-1221	0.5	ug/L
PCB-1248	0.5	ug/L
PCB-1232	0.5	ug/L
PCB-1254	0.5	ug/L
PCB-1242	0.5	ug/L
PCB-1260	0.5	ug/L

Method Limit Group Report

Location Code: 580
STL Seattle

Limit Group Description: mss 8270_Solids_RL/MDL

Type: MDL **Created:** 9/15/2006 2:29:00 PM **Active:** 8/15/2006 2:31:14 PM
Initial Prep: 20 **Unit:** g **Final Prep:** 2 **Unit:** mL

Analyte Description	Limit	Units
Dimethyl phthalate	0.77	ug/Kg
Hexachloroethane	2.1	ug/Kg
1,2-Dichlorobenzene	1.7	ug/Kg
N-Nitrosodimethylamine	48	ug/Kg
3,3'-Dichlorobenzidine	0.91	ug/Kg
Decane	13	ug/Kg
2,4-Dinitrophenol	20.5	ug/Kg
Acetophenone	9.5	ug/Kg
4-Nitrophenol	26	ug/Kg
Nitrobenzene	1.5	ug/Kg
2-Chloronaphthalene	0.19	ug/Kg
Bis(2-chloroethyl)ether	3	ug/Kg
Anthracene	0.43	ug/Kg
2,4,5-Trichlorophenol	2.3	ug/Kg
2,4,6-Trichlorophenol	3.3	ug/Kg
Indeno[1,2,3-cd]pyrene	1.2	ug/Kg
Diethyl phthalate	0.72	ug/Kg
1,2,4-Trichlorobenzene	0.99	ug/Kg
2,6-Dinitrotoluene	1.9	ug/Kg
Phenol	2.7	ug/Kg
Isophorone	2.6	ug/Kg
1,3-Dichlorobenzene	1.2	ug/Kg
Benzofluoranthene	1	ug/Kg
Bis(2-ethylhexyl) phthalate	24	ug/Kg
Di-n-butyl phthalate	1.3	ug/Kg
Butyl benzyl phthalate	2.9	ug/Kg
4-Chlorophenyl phenyl ether	1.6	ug/Kg
4-Chloro-3-methylphenol	2.2	ug/Kg
2,3,5,6-Tetrachlorophenol	2.6	ug/Kg
2,3,4,6-Tetrachlorophenol	2	ug/Kg
2,3-Dichlorobenzenamine	9.4	ug/Kg
n-Octadecane	15	ug/Kg
Naphthalene	0.57	ug/Kg
Acenaphthene	0.57	ug/Kg
Cyclohexanone	10	ug/Kg
2-Methylnaphthalene	0.31	ug/Kg
Hexachlorobenzene	1.1	ug/Kg
Benzoic acid	83	ug/Kg
Pyrene	0.27	ug/Kg
N-Nitrosodi-n-propylamine	2.6	ug/Kg
2-Methylphenol	2.8	ug/Kg
Benzo[b]fluoranthene	0.54	ug/Kg
1,1'-Biphenyl	10	ug/Kg
Fluoranthene	0.31	ug/Kg
3-Nitroaniline	2.9	ug/Kg

1-Methylnaphthalene	0.87	ug/Kg
Phenanthrene	0.4	ug/Kg
2,4-Dichlorophenol	1.9	ug/Kg
Benzo[g,h,i]perylene	0.73	ug/Kg
Azobenzene	1.3	ug/Kg
Benzo[k]fluoranthene	0.69	ug/Kg
2,4-Dinitrotoluene	1.4	ug/Kg
4-Chloroaniline	2.7	ug/Kg
4,6-Dinitro-2-methylphenol	27	ug/Kg
Hexachlorocyclopentadiene	2.5	ug/Kg
Chrysene	0.75	ug/Kg
Benzo[a]anthracene	0.65	ug/Kg
Dibenzofuran	1.7	ug/Kg
2,2'-oxybis(2-chloropropane)	3.4	ug/Kg
Pentachlorophenol	3.1	ug/Kg
2-Nitroaniline	1.9	ug/Kg
4-Bromophenyl phenyl ether	1	ug/Kg
2-Chlorophenol	2.3	ug/Kg
Pyridine	25	ug/Kg
Benzidine	31.5	ug/Kg
Acenaphthylene	0.23	ug/Kg
N-Nitrosodiphenylamine	1.5	ug/Kg
Aniline	1.2	ug/Kg
Bis(2-chloroethoxy)methane	2.5	ug/Kg
4-Nitroaniline	1.9	ug/Kg
1,4-Dichlorobenzene	0.76	ug/Kg
Benzo[a]pyrene	0.85	ug/Kg
3 & 4 Methylphenol	5.3	ug/Kg
Hexachlorobutadiene	1.3	ug/Kg
Benzyl alcohol	3	ug/Kg
Carbazole	3.3	ug/Kg
Di-n-octyl phthalate	3.3	ug/Kg
Fluorene	0.26	ug/Kg
Benzaldehyde	9.6	ug/Kg
2,4-Dimethylphenol	1.9	ug/Kg
Dibenz(a,h)anthracene	1.2	ug/Kg
2-Nitrophenol	2.3	ug/Kg

Type:	RL	Created:	9/15/2006 2:30:00 PM	Active:	8/15/2006 2:30:41 PM	
Initial Prep:	20	Unit:	g	Final Prep:	2	Unit: mL
Analyte Description	Limit		Units			
Dimethyl phthalate	10		ug/Kg			
Hexachloroethane	5		ug/Kg			
1,2-Dichlorobenzene	5		ug/Kg			
N-Nitrosodimethylamine	50		ug/Kg			
3,3'-Dichlorobenzidine	20		ug/Kg			
2,4-Dinitrophenol	50		ug/Kg			
4-Nitrophenol	50		ug/Kg			
Nitrobenzene	10		ug/Kg			
2-Chloronaphthalene	2		ug/Kg			
Bis(2-chloroethyl)ether	10		ug/Kg			
Anthracene	2		ug/Kg			

2,4,5-Trichlorophenol	5	ug/Kg
2,4,6-Trichlorophenol	5	ug/Kg
Indeno[1,2,3-cd]pyrene	2	ug/Kg
Diethyl phthalate	20	ug/Kg
1,2,4-Trichlorobenzene	5	ug/Kg
2,6-Dinitrotoluene	10	ug/Kg
Phenol	5	ug/Kg
Isophorone	5	ug/Kg
1,3-Dichlorobenzene	5	ug/Kg
Benzofluoranthene	4	ug/Kg
Bis(2-ethylhexyl) phthalate	30	ug/Kg
Di-n-butyl phthalate	20	ug/Kg
Butyl benzyl phthalate	20	ug/Kg
4-Chlorophenyl phenyl ether	10	ug/Kg
4-Chloro-3-methylphenol	5	ug/Kg
2,3,5,6-Tetrachlorophenol	10	ug/Kg

2,3,4,6-Tetrachlorophenol	10	ug/Kg
Naphthalene	2	ug/Kg
Acenaphthene	2	ug/Kg
Cyclohexanone	30	ug/Kg
2-Methylnaphthalene	2	ug/Kg
Hexachlorobenzene	2	ug/Kg
Benzoic acid	60	ug/Kg
Pyrene	2	ug/Kg
N-Nitrosodi-n-propylamine	5	ug/Kg
2-Methylphenol	5	ug/Kg
Benzo[b]fluoranthene	2	ug/Kg
Fluoranthene	2	ug/Kg
3-Nitroaniline	10	ug/Kg
1-Methylnaphthalene	2	ug/Kg
Phenanthrene	2	ug/Kg
2,4-Dichlorophenol	5	ug/Kg
Benzo[g,h,i]perylene	2	ug/Kg
Azobenzene	10	ug/Kg
Benzo[k]fluoranthene	2	ug/Kg
2,4-Dinitrotoluene	10	ug/Kg
4-Chloroaniline	10	ug/Kg
4,6-Dinitro-2-methylphenol	50	ug/Kg
Hexachlorocyclopentadiene	5	ug/Kg
Chrysene	2	ug/Kg
Benzo[a]anthracene	2	ug/Kg
Dibenzofuran	5	ug/Kg
2,2'-oxybis(2-chloropropane)	25	ug/Kg
Pentachlorophenol	20	ug/Kg
2-Nitroaniline	5	ug/Kg
4-Bromophenyl phenyl ether	10	ug/Kg
2-Chlorophenol	5	ug/Kg
Pyridine	50	ug/Kg
Benzidine	25	ug/Kg
Acenaphthylene	2	ug/Kg
N-Nitrosodiphenylamine	5	ug/Kg
Aniline	10	ug/Kg
Bis(2-chloroethoxy)methane	10	ug/Kg
4-Nitroaniline	10	ug/Kg
1,4-Dichlorobenzene	5	ug/Kg
Benzo[a]pyrene	2	ug/Kg
3 & 4 Methylphenol	6	ug/Kg
2,6-Dichlorophenol	10	ug/Kg
Hexachlorobutadiene	5	ug/Kg
Benzyl alcohol	5	ug/Kg
Carbazole	10	ug/Kg
Di-n-octyl phthalate	20	ug/Kg
Fluorene	2	ug/Kg
2,4-Dimethylphenol	2	ug/Kg
Dibenz(a,h)anthracene	2	ug/Kg
2-Nitrophenol	5	ug/Kg

Method Limit Group Report

Location Code: 580

STL Seattle

Limit Group Description: mss 8270&625_Waters_RL/MDL**Type:** MDL**Created:** 4/3/2006 4:02:00 PM**Active:** 8/31/2006 11:53:12 AM**Initial Prep:** 1000**Unit:** mL**Final Prep:** 1**Unit:** mL

Analyte Description	Limit	Units
Dimethyl phthalate	0.012	ug/L
Hexachloroethane	0.013	ug/L
1,2-Dichlorobenzene	0.011	ug/L
N-Nitrosodimethylamine	0.065	ug/L
3,3'-Dichlorobenzidine	0.16	ug/L
Decane	0.011	ug/L
2,4-Dinitrophenol	0.058	ug/L
Acetophenone	0.012	ug/L
4-Nitrophenol	0.16	ug/L
Nitrobenzene	0.0075	ug/L
2-Chloronaphthalene	0.003	ug/L
Bis(2-chloroethyl)ether	0.018	ug/L
Anthracene	0.0019	ug/L
1,2-Diphenylhydrazine	0.016	ug/L
2,4,5-Trichlorophenol	0.0085	ug/L
2,4,6-Trichlorophenol	0.01	ug/L
Indeno[1,2,3-cd]pyrene	0.0051	ug/L
Diethyl phthalate	0.0093	ug/L
1,2,4-Trichlorobenzene	0.01	ug/L
2,6-Dinitrotoluene	0.014	ug/L
Phenol	0.0074	ug/L
Isophorone	0.011	ug/L
1,3-Dichlorobenzene	0.011	ug/L
Benzofluoranthene	0.0055	ug/L
Bis(2-ethylhexyl) phthalate	0.032	ug/L
Di-n-butyl phthalate	0.0088	ug/L
Butyl benzyl phthalate	0.024	ug/L
4-Chlorophenyl phenyl ether	0.012	ug/L
4-Chloro-3-methylphenol	0.014	ug/L
2,3,5,6-Tetrachlorophenol	0.018	ug/L
2,3,4,6-Tetrachlorophenol	0.0083	ug/L
2,3-Dichlorobenzenamine	0.022	ug/L
n-Octadecane	0.009	ug/L
Naphthalene	0.0014	ug/L
Acenaphthene	0.0012	ug/L
Cyclohexanone	0.015	ug/L
2-Methylnaphthalene	0.0055	ug/L
Hexachlorobenzene	0.0082	ug/L
Benzoic acid	0.021	ug/L
Pyrene	0.002	ug/L
N-Nitrosodi-n-propylamine	0.02	ug/L
2-Methylphenol	0.038	ug/L
Benzo[b]fluoranthene	0.0046	ug/L
1,1'-Biphenyl	0.013	ug/L
Fluoranthene	0.0027	ug/L

3-Nitroaniline	0.056	ug/L
1-Methylnaphthalene	0.0052	ug/L
Phenanthrene	0.0024	ug/L
2,4-Dichlorophenol	0.013	ug/L
Benzo[g,h,i]perylene	0.006	ug/L
Azobenzene	0.016	ug/L
Benzo[k]fluoranthene	0.0055	ug/L
2,4-Dinitrotoluene	0.012	ug/L
4-Chloroaniline	0.019	ug/L
4,6-Dinitro-2-methylphenol	0.053	ug/L
Hexachlorocyclopentadiene	0.012	ug/L
Chrysene	0.0045	ug/L
Benzo[a]anthracene	0.0033	ug/L
Dibenzofuran	0.0098	ug/L
2,2'-oxybis(2-chloropropane)	0.0088	ug/L
Pentachlorophenol	0.013	ug/L
2-Nitroaniline	0.011	ug/L
4-Bromophenyl phenyl ether	0.01	ug/L
2-Chlorophenol	0.022	ug/L
Pyridine	0.12	ug/L
Benzidine	0.47	ug/L
Acenaphthylene	0.0026	ug/L
N-Nitrosodiphenylamine	0.013	ug/L
Aniline	0.058	ug/L
Bis(2-chloroethoxy)methane	0.0095	ug/L
4-Nitroaniline	0.018	ug/L
1,4-Dichlorobenzene	0.012	ug/L
Benzo[a]pyrene	0.0027	ug/L
3 & 4 Methylphenol	0.017	ug/L
2,6-Dichlorophenol	0.2	ug/L
Hexachlorobutadiene	0.016	ug/L
Benzyl alcohol	0.013	ug/L
Carbazole	0.009	ug/L
Di-n-octyl phthalate	0.018	ug/L
Fluorene	0.0042	ug/L
Benzaldehyde	0.011	ug/L
2,4-Dimethylphenol	0.018	ug/L
Dibenz(a,h)anthracene	0.0046	ug/L
2-Nitrophenol	0.021	ug/L
Type: RL	Created: 8/31/2006 3:07:00 PM	Active: 8/31/2006 3:08:23 PM
Initial Prep: 1000	Unit: mL	Final Prep: 1 Unit: mL
Analyte Description	Limit	Units
Dimethyl phthalate	0.2	ug/L
Hexachloroethane	0.3	ug/L
1,2-Dichlorobenzene	0.2	ug/L
N-Nitrosodimethylamine	1	ug/L
3,3'-Dichlorobenzidine	1	ug/L
2,3,4-Trichlorophenol	0.2	ug/L
Decane	0.3	ug/L
2,4-Dinitrophenol	2.5	ug/L
Acetophenone	0.2	ug/L

4-Nitrophenol	1	ug/L
Nitrobenzene	0.2	ug/L
2-Chloronaphthalene	0.03	ug/L
Bis(2-chloroethyl)ether	0.2	ug/L
Anthracene	0.02	ug/L
2,4,5-Trichlorophenol	0.2	ug/L
2,4,6-Trichlorophenol	0.3	ug/L
Indeno[1,2,3-cd]pyrene	0.03	ug/L
Diethyl phthalate	0.2	ug/L
1,2,4-Trichlorobenzene	0.2	ug/L
2,6-Dinitrotoluene	0.2	ug/L
Phenol	0.3	ug/L
Isophorone	0.2	ug/L
1,3-Dichlorobenzene	0.2	ug/L
Benzofluoranthene	0.04	ug/L
Bis(2-ethylhexyl) phthalate	1.5	ug/L

2,3,6-Trichlorophenol	0.2	ug/L
Di-n-butyl phthalate	0.2	ug/L
Butyl benzyl phthalate	0.3	ug/L
4-Chlorophenyl phenyl ether	0.2	ug/L
4-Chloro-3-methylphenol	0.2	ug/L
2,3,5,6-Tetrachlorophenol	0.2	ug/L
2,3,4,6-Tetrachlorophenol	0.35	ug/L
2,3-Dichlorobenzenamine	1	ug/L
3,4,5-Trichlorophenol	0.2	ug/L
n-Octadecane	0.2	ug/L
Naphthalene	0.2	ug/L
Acenaphthene	0.05	ug/L
Cyclohexanone	0.5	ug/L
2-Methylnaphthalene	0.1	ug/L
Hexachlorobenzene	0.2	ug/L
Benzoic acid	1	ug/L
Pyrene	0.03	ug/L
N-Nitrosodi-n-propylamine	0.2	ug/L
2-Methylphenol	0.2	ug/L
Benzo[b]fluoranthene	0.04	ug/L
1,1'-Biphenyl	1	ug/L
Fluoranthene	0.025	ug/L
3-Nitroaniline	0.2	ug/L
Caprolactam	0.2	ug/L
1-Methylnaphthalene	0.03	ug/L
Phenanthrene	0.04	ug/L
2,4-Dichlorophenol	0.2	ug/L
Benzo[g,h,i]perylene	0.03	ug/L
Atrazine	0.1	ug/L
Azobenzene	0.5	ug/L
2,3,5-Trichlorophenol	0.2	ug/L
Benzo[k]fluoranthene	0.03	ug/L
2,4-Dinitrotoluene	0.2	ug/L
4-Chloroaniline	0.2	ug/L
4,6-Dinitro-2-methylphenol	2	ug/L
Hexachlorocyclopentadiene	1	ug/L
Chrysene	0.02	ug/L
Benzo[a]anthracene	0.03	ug/L
Dibenzofuran	0.2	ug/L
2,2'-oxybis(2-chloropropane)	0.2	ug/L
Pentachlorophenol	0.35	ug/L
2-Nitroaniline	0.2	ug/L
4-Bromophenyl phenyl ether	0.2	ug/L
2-Chlorophenol	0.2	ug/L
Pyridine	1	ug/L
Benzidine	1.5	ug/L
Acenaphthylene	0.04	ug/L
N-Nitrosodiphenylamine	0.2	ug/L
Aniline	0.3	ug/L
Bis(2-chloroethoxy)methane	0.2	ug/L
4-Nitroaniline	0.3	ug/L
1,4-Dichlorobenzene	0.2	ug/L
Benzo[a]pyrene	0.02	ug/L
3 & 4 Methylphenol	0.4	ug/L

2,6-Dichlorophenol	0.2	ug/L
Hexachlorobutadiene	0.3	ug/L
Benzyl alcohol	0.2	ug/L
Carbazole	0.2	ug/L
Di-n-octyl phthalate	0.2	ug/L
Fluorene	0.03	ug/L
Benzaldehyde	0.2	ug/L
2,4-Dimethylphenol	1	ug/L
Dibenz(a,h)anthracene	0.03	ug/L
2-Nitrophenol	0.2	ug/L

Laucks Testing Laboratories, Inc. Detection Limits

LAUCKS TESTING LABORATORIES, INC. - PRICE BOOK ANALYTES - Target Control Limits																	
Determination	Reporting Units	Analyte	CAS#	Type	Spiked?	PQL	MDL	Blank	MS/MSD			BS/BSD			Duplicate	Con.	Surrogate
									LCL	UCL	RPD	LCL	UCL	RPD	RPD		LCL UCL
6010B Metals Soil TAL list	mg/Kg	Aluminum	7429-90-5	A	X	50	3.21	25	75	125	20	80	120	20	20	250	
6010B Metals Soil TAL list	mg/Kg	Antimony	7440-36-0	A	X	6	0.193	3	75	125	20	80	120	20	20	30	
6010B Metals Soil TAL list	mg/Kg	Arsenic	7440-38-2	A	X	2	0.356	0.5	75	125	20	80	120	20	20	10	
6010B Metals Soil TAL list	mg/Kg	Barium	7440-39-3	A	X	20	0.165	10	75	125	20	80	120	20	20	100	
6010B Metals Soil TAL list	mg/Kg	Beryllium	7440-41-7	A	X	0.5	0.0508	0.25	75	125	20	80	120	20	20	2.5	
6010B Metals Soil TAL list	mg/Kg	Cadmium	7440-43-9	A	X	1	0.0757	0.25	75	125	20	80	120	20	20	5	
6010B Metals Soil TAL list	mg/Kg	Calcium	7440-70-2	A	X	500	2.56	250	75	125	20	80	120	20	20	2500	
6010B Metals Soil TAL list	mg/Kg	Chromium	7440-47-3	A	X	1	0.0444	0.5	75	125	20	80	120	20	20	5	
6010B Metals Soil TAL list	mg/Kg	Cobalt	7440-48-4	A	X	5	0.0678	2.5	75	125	20	80	120	20	20	25	
6010B Metals Soil TAL list	mg/Kg	Copper	7440-50-8	A	X	2.5	0.0306	1.25	75	125	20	80	120	20	20	12.5	
6010B Metals Soil TAL list	mg/Kg	Iron	7439-89-6	A	X	20	1.4	10	75	125	20	80	120	20	20	100	
6010B Metals Soil TAL list	mg/Kg	Lead	7439-92-1	A	X	1	0.227	0.5	75	125	20	80	120	20	20	5	
6010B Metals Soil TAL list	mg/Kg	Magnesium	7439-95-4	A	X	500	0.43	250	75	125	20	80	120	20	20	2500	
6010B Metals Soil TAL list	mg/Kg	Manganese	7439-96-5	A	X	1.5	0.0153	0.75	75	125	20	80	120	20	20	7.5	
6010B Metals Soil TAL list	mg/Kg	Nickel	7440-02-0	A	X	4	0.0825	2	75	125	20	80	120	20	20	20	
6010B Metals Soil TAL list	mg/Kg	Potassium	9/7/7440	A	X	500	0.82	250	75	125	20	80	120	20	20	2500	
6010B Metals Soil TAL list	mg/Kg	Selenium	7782-49-2	A	X	1	0.306	0.5	75	125	20	80	120	20	20	5	
6010B Metals Soil TAL list	mg/Kg	Silver	7440-22-4	A	X	1	0.04	0.5	75	125	20	80	120	20	20	5	
6010B Metals Soil TAL list	mg/Kg	Sodium	7440-23-5	A	X	500	12.2	250	75	125	20	80	120	20	20	2500	
6010B Metals Soil TAL list	mg/Kg	Thallium	7440-28-0	A	X	2	0.486	0.5	75	125	20	80	120	20	20	10	
6010B Metals Soil TAL list	mg/Kg	Vanadium	7440-62-2	A	X	5	0.0422	2.5	75	125	20	80	120	20	20	25	
6010B Metals Soil TAL list	mg/Kg	Zinc	7440-66-6	A	X	4	0.26	1	75	125	20	80	120	20	20	20	
6020 Metals Soil TAL list-3050B	mg/Kg	Aluminum	7429-90-5	A	X	25	7.2	12.5	75	125	20	80	120	20	20	125	
6020 Metals Soil TAL list-3050B	mg/Kg	Antimony	7440-36-0	A	X	0.5	0.025	0.25	75	125	20	80	120	20	20	2.5	
6020 Metals Soil TAL list-3050B	mg/Kg	Arsenic	7440-38-2	A	X	0.5	0.025	0.25	75	125	20	80	120	20	20	2.5	
6020 Metals Soil TAL list-3050B	mg/Kg	Barium	7440-39-3	A	X	0.5	0.16	0.25	75	125	20	80	120	20	20	2.5	
6020 Metals Soil TAL list-3050B	mg/Kg	Beryllium	7440-41-7	A	X	0.5	0.019	0.25	75	125	20	80	120	20	20	2.5	
6020 Metals Soil TAL list-3050B	mg/Kg	Cadmium	7440-43-9	A	X	0.5	0.037	0.25	75	125	20	80	120	20	20	2.5	
6020 Metals Soil TAL list-3050B	mg/Kg	Calcium	7440-70-2	A	X	50	7.8	25	75	125	20	80	120	20	20	250	
6020 Metals Soil TAL list-3050B	mg/Kg	Chromium	7440-47-3	A	X	0.5	0.019	0.25	75	125	20	80	120	20	20	2.5	
6020 Metals Soil TAL list-3050B	mg/Kg	Cobalt	7440-48-4	A	X	0.5	0.01	0.25	75	125	20	80	120	20	20	2.5	
6020 Metals Soil TAL list-3050B	mg/Kg	Copper	7440-50-8	A	X	1	0.039	0.5	75	125	20	80	120	20	20	5	
6020 Metals Soil TAL list-3050B	mg/Kg	Iron	7439-89-6	A	X	25	4.6	12.5	75	125	20	80	120	20	20	125	
6020 Metals Soil TAL list-3050B	mg/Kg	Lead	7439-92-1	A	X	0.5	0.016	0.25	75	125	20	80	120	20	20	2.5	
6020 Metals Soil TAL list-3050B	mg/Kg	Magnesium	7439-95-4	A	X	50	1.9	25	75	125	20	80	120	20	20	250	
6020 Metals Soil TAL list-3050B	mg/Kg	Manganese	7439-96-5	A	X	2.5	0.28	1.25	75	125	20	80	120	20	20	12.5	
6020 Metals Soil TAL list-3050B	mg/Kg	Nickel	7440-02-0	A	X	0.5	0.012	0.25	75	125	20	80	120	20	20	2.5	
6020 Metals Soil TAL list-3050B	mg/Kg	Potassium	9/7/7440	A	X	50	4.3	25	75	125	20	80	120	20	20	250	
6020 Metals Soil TAL list-3050B	mg/Kg	Selenium	7782-49-2	A	X	0.5	0.086	0.25	75	125	20	80	120	20	20	2.5	
6020 Metals Soil TAL list-3050B	mg/Kg	Silver	7440-22-4	A	X	0.5	0.047	0.25	75	125	20	80	120	20	20	2.5	
6020 Metals Soil TAL list-3050B	mg/Kg	Sodium	7440-23-5	A	X	50	3.7	25	75	125	20	80	120	20	20	250	
6020 Metals Soil TAL list-3050B	mg/Kg	Thallium	7440-28-0	A	X	0.5	0.013	0.25	75	125	20	80	120	20	20	2.5	
6020 Metals Soil TAL list-3050B	mg/Kg	Vanadium	7440-62-2	A	X	1	0.011	0.5	75	125	20	80	120	20	20	5	
6020 Metals Soil TAL list-3050B	mg/Kg	Zinc	7440-66-6	A	X	5	2.1	2.5	75	125	20	80	120	20	20	25	
7471A Mercury in Soil	mg/Kg	Mercury	7439-97-6	A	X	0.1	0.00546	0.05	85	115	20	90	110				
8082 PCB Aroclors (Routine) Soil	ug/kg	Aroclor-1016	12674-11-2	A	X	17	3.9	8.325	42	128	16	77	124				
8082 PCB Aroclors (Routine) Soil	ug/kg	Aroclor-1221	11104-28-2	A	X	17	4.6	8.325	0	0	0	0	0				
8082 PCB Aroclors (Routine) Soil	ug/kg	Aroclor-1232	11141-16-5	A	X	17	3.4	8.325	0	0	0	0	0				
8082 PCB Aroclors (Routine) Soil	ug/kg	Aroclor-1242	53469-21-9	A	X	17	4.5	8.325	0	0	0	0	0				
8082 PCB Aroclors (Routine) Soil	ug/kg	Aroclor-1248	12672-29-6	A	X	17	4.3	8.325	0	0	0	0	0				
8082 PCB Aroclors (Routine) Soil	ug/kg	Aroclor-1254	11097-69-1	A	X	17	2.6	8.325	0	0	0	0	0				
8082 PCB Aroclors (Routine) Soil	ug/kg	Aroclor-1260	11096-82-5	A	X	17	3.6	8.325	49	158	31	66	168				
8082 PCB Aroclors (Routine) Soil	ug/kg	Decachlorobiphenyl	2051-24-3	S	X				0	0	0	0	0			20	160
8082 PCB Aroclors (Routine) Soil	ug/kg	Tetrachloro-m-xylene	877-09-8	S	X				0	0	0	0	0			20	150

8260-3 VOAs soil extended list	ug/kg	1,1,1,2-Tetrachloroethane	630-20-6	A	X	3	0.81	1.5	75	125	30	75	125					
8260-3 VOAs soil extended list	ug/kg	1,1,1-Trichloroethane	71-55-6	A	X	3	0.56	1.5	70	135	30	70	135					
8260-3 VOAs soil extended list	ug/kg	1,1,2,2-Tetrachloroethane	79-34-5	A	X	3	0.64	1.5	55	130	30	55	130					
8260-3 VOAs soil extended list	ug/kg	1,1,2-Trichloroethane	79-00-5	A	X	3	0.68	1.5	60	125	30	60	125					
8260-3 VOAs soil extended list	ug/kg	1,1-Dichloroethane	75-34-3	A	X	3	0.62	1.5	75	125	30	75	125					
8260-3 VOAs soil extended list	ug/kg	1,1-Dichloroethene	75-35-4	A	X	3	0.36	1.5	65	135	30	65	135					
8260-3 VOAs soil extended list	ug/kg	1,1-Dichloropropene	563-58-6	A	X	3	0.64	1.5	70	135	30	70	135					
8260-3 VOAs soil extended list	ug/kg	1,2,3-Trichlorobenzene	87-61-6	A	X	3	0.81	1.5	60	135	30	60	135					
8260-3 VOAs soil extended list	ug/kg	1,2,3-Trichloropropane	96-18-4	A	X	3	0.92	1.5	65	130	30	65	130					
8260-3 VOAs soil extended list	ug/kg	1,2,4-Trichlorobenzene	120-82-1	A	X	3	0.73	1.5	65	130	30	65	130					
8260-3 VOAs soil extended list	ug/kg	1,2,4-Trimethylbenzene	95-63-6	A	X	3	0.55	1.5	65	135	30	65	135					
8260-3 VOAs soil extended list	ug/kg	1,2-Dibromo-3-chloropropane	96-12-8	A	X	3	0.73	1.5	40	135	30	40	135					
8260-3 VOAs soil extended list	ug/kg	1,2-Dibromoethane	106-93-4	A	X	3	0.57	1.5	70	125	30	70	125					
8260-3 VOAs soil extended list	ug/kg	1,2-Dichlorobenzene	95-50-1	A	X	3	0.87	1.5	75	120	30	75	120					
8260-3 VOAs soil extended list	ug/kg	1,2-Dichloroethane	107-06-2	A	X	3	0.42	1.5	70	135	30	70	135					
8260-3 VOAs soil extended list	ug/kg	1,2-Dichloropropane	78-87-5	A	X	3	0.55	1.5	70	120	30	70	120					
8260-3 VOAs soil extended list	ug/kg	1,3,5-Trimethylbenzene	108-67-8	A	X	3	0.68	1.5	65	135	30	65	135					
8260-3 VOAs soil extended list	ug/kg	1,3-Dichlorobenzene	541-73-1	A	X	3	0.82	1.5	70	125	30	70	125					
8260-3 VOAs soil extended list	ug/kg	1,3-Dichloropropane	142-28-9	A	X	3	0.77	1.5	75	125	30	75	125					
8260-3 VOAs soil extended list	ug/kg	1,4-Dichlorobenzene	106-46-7	A	X	3	0.77	1.5	70	125	30	70	125					
8260-3 VOAs soil extended list	ug/kg	2,2-Dichloropropane	594-20-7	A	X	3	0.74	1.5	65	135	30	65	135					
8260-3 VOAs soil extended list	ug/kg	2-Butanone	78-93-3	A	X	10	0.69	5	30	160	30	30	160					
8260-3 VOAs soil extended list	ug/kg	2-Chlorotoluene	95-49-8	A	X	3	0.64	1.5	70	130	30	70	130					
8260-3 VOAs soil extended list	ug/kg	2-Hexanone	591-78-6	A	X	10	0.93	5	45	145	30	45	145					
8260-3 VOAs soil extended list	ug/kg	4-Chlorotoluene	106-43-4	A	X	3	0.71	1.5	75	125	30	75	125					
8260-3 VOAs soil extended list	ug/kg	4-Isopropyltoluene	99-87-6	A	X	3	0.69	1.5	75	135	30	75	135					
8260-3 VOAs soil extended list	ug/kg	4-Methyl-2-pentanone	108-10-1	A	X	10	0.48	5	45	145	30	45	145					
8260-3 VOAs soil extended list	ug/kg	Acetone	67-64-1	A	X	10	1.2	5	20	160	30	20	160					
8260-3 VOAs soil extended list	ug/kg	Benzene	71-43-2	A	X	3	0.57	1.5	75	125	30	75	125					
8260-3 VOAs soil extended list	ug/kg	Bromobenzene	108-86-1	A	X	3	0.61	1.5	65	120	30	65	120					
8260-3 VOAs soil extended list	ug/kg	Bromochloromethane	74-97-5	A	X	3	0.69	1.5	70	125	30	70	125					
8260-3 VOAs soil extended list	ug/kg	Bromodichloromethane	75-27-4	A	X	3	0.41	1.5	70	130	30	70	130					
8260-3 VOAs soil extended list	ug/kg	Bromoform	75-25-2	A	X	3	0.44	1.5	55	135	30	55	135					
8260-3 VOAs soil extended list	ug/kg	Bromomethane	74-83-9	A	X	3	0.69	1.5	30	160	30	30	160					
8260-3 VOAs soil extended list	ug/kg	Carbon disulfide	75-15-0	A	X	3	1.3	1.5	45	160	30	45	160					
8260-3 VOAs soil extended list	ug/kg	Carbon tetrachloride	56-23-5	A	X	3	0.42	1.5	65	135	30	65	135					
8260-3 VOAs soil extended list	ug/kg	Chlorobenzene	108-90-7	A	X	3	0.54	1.5	75	125	30	75	125					
8260-3 VOAs soil extended list	ug/kg	Chloroethane	75-00-3	A	X	3	1.1	1.5	40	155	30	40	155					
8260-3 VOAs soil extended list	ug/kg	Chloroform	67-66-3	A	X	3	0.49	1.5	70	125	30	70	125					
8260-3 VOAs soil extended list	ug/kg	Chloromethane	74-87-3	A	X	3	0.81	1.5	50	130	30	50	130					
8260-3 VOAs soil extended list	ug/kg	cis-1,2-Dichloroethene	156-59-2	A	X	3	0.54	1.5	65	125	30	65	125					
8260-3 VOAs soil extended list	ug/kg	cis-1,3-Dichloropropene	10061-01-5	A	X	3	0.51	1.5	70	125	30	70	125					
8260-3 VOAs soil extended list	ug/kg	Dibromochloromethane	124-48-1	A		3	0.63	1.5										
8260-3 VOAs soil extended list	ug/kg	Dibromomethane	74-95-3	A	X	3	0.44	1.5	75	130	30	75	130					
8260-3 VOAs soil extended list	ug/kg	Dichlorodifluoromethane	75-71-8	A	X	3	0.78	1.5	35	135	30	35	135					
8260-3 VOAs soil extended list	ug/kg	Ethylbenzene	100-41-4	A	X	3	0.55	1.5	75	125	30	75	125					
8260-3 VOAs soil extended list	ug/kg	Hexachlorobutadiene	87-68-3	A	X	3	0.75	1.5	55	140	30	55	140					
8260-3 VOAs soil extended list	ug/kg	Isopropylbenzene	98-82-8	A	X	3	0.64	1.5	75	130	30	75	130					
8260-3 VOAs soil extended list	ug/kg	m,p-Xylene	179601-23-1	A	X	6	1.4	1.5	80	125	30	80	125					
8260-3 VOAs soil extended list	ug/kg	Methylene chloride	75-09-2	A	X	3	2.3	1.5	55	140	30	55	140					
8260-3 VOAs soil extended list	ug/kg	Naphthalene	91-20-3	A	X	3	0.6	1.5	40	125	30	40	125					
8260-3 VOAs soil extended list	ug/kg	n-Butylbenzene	104-51-8	A	X	3	0.67	1.5	65	140	30	65	140					
8260-3 VOAs soil extended list	ug/kg	n-Propylbenzene	103-65-1	A	X	3	0.63	1.5	65	135	30	65	135					
8260-3 VOAs soil extended list	ug/kg	o-Xylene	95-47-6	A	X	3	0.77	1.5	75	125	30	75	125					
8260-3 VOAs soil extended list	ug/kg	sec-Butylbenzene	135-98-8	A	X	3	0.58	1.5	65	130	30	65	130					
8260-3 VOAs soil extended list	ug/kg	Styrene	100-42-5	A	X	3	0.64	1.5	75	125	30	75	125					
8260-3 VOAs soil extended list	ug/kg	tert-Butylbenzene	98-06-6	A	X	3	0.7	1.5	65	130	30	65	130					
8260-3 VOAs soil extended list	ug/kg	Tetrachloroethene	127-18-4	A	X	3	0.98	1.5	65	140	30	65	140					

8260-3 VOAs soil extended list	ug/kg	Toluene	108-88-3	A	X	3	0.65	1.5	70	125	30	70	125						
8260-3 VOAs soil extended list	ug/kg	trans-1,2-Dichloroethene	156-60-5	A	X	3	0.62	1.5	65	135	30	65	135						
8260-3 VOAs soil extended list	ug/kg	trans-1,3-Dichloropropene	10061-02-6	A	X	3	0.65	1.5	65	125	30	65	125						
8260-3 VOAs soil extended list	ug/kg	Trichloroethene	79-01-6	A	X	3	0.54	1.5	75	125	30	75	125						
8260-3 VOAs soil extended list	ug/kg	Trichlorofluoromethane	75-69-4	A	X	3	0.51	1.5	25	185	30	25	185						
8260-3 VOAs soil extended list	ug/kg	Vinyl chloride	75-01-4	A	X	3	0.68	1.5	60	125	30	60	125						
8260-3 VOAs soil extended list	ug/kg	1,2-Dichloroethane-d4	17060-07-0	S	X				0	0		0	0					52	149
8260-3 VOAs soil extended list	ug/kg	4-Bromofluorobenzene	460-00-4	S	X				0	0		0	0					85	120
8260-3 VOAs soil extended list	ug/kg	Dibromofluoromethane	1868-53-7	S	X				0	0		0	0					65	135
8260-3 VOAs soil extended list	ug/kg	Toluene-d8	2037-26-5	S	X				0	0		0	0					85	115
8270 (MSPNA) (SIM level) Soil	ug/kg	1-Methylnaphthalene	90-12-0	A	X	6.7		1.2	3.35	45	105	30	45	105	30				
8270 (MSPNA) (SIM level) Soil	ug/kg	2-Methylnaphthalene	91-57-6	A	X	6.7	1.8	3.35	45	105	30	45	105	30					
8270 (MSPNA) (SIM level) Soil	ug/kg	Acenaphthene	83-32-9	A	X	6.7	1.3	3.35	45	110	30	45	110	30					
8270 (MSPNA) (SIM level) Soil	ug/kg	Acenaphthylene	208-96-8	A	X	6.7	0.72	3.35	45	105	30	45	105	30					
8270 (MSPNA) (SIM level) Soil	ug/kg	Anthracene	120-12-7	A	X	6.7	0.95	3.35	55	105	30	55	105	30					
8270 (MSPNA) (SIM level) Soil	ug/kg	Benzo(a)anthracene	56-55-3	A	X	6.7	1	3.35	50	110	30	50	110	30					
8270 (MSPNA) (SIM level) Soil	ug/kg	Benzo(a)pyrene	50-32-8	A	X	6.7	1.1	3.35	50	110	30	50	110	30					
8270 (MSPNA) (SIM level) Soil	ug/kg	Benzo(b)fluoranthene	205-99-2	A	X	6.7	1	3.35	45	115	30	45	115	30					
8270 (MSPNA) (SIM level) Soil	ug/kg	Benzo(g,h,i)perylene	191-24-2	A	X	6.7	1.1	3.35	40	125	30	40	125	30					
8270 (MSPNA) (SIM level) Soil	ug/kg	Benzo(k)fluoranthene	207-08-9	A	X	6.7	0.52	3.35	45	125	30	45	125	30					
8270 (MSPNA) (SIM level) Soil	ug/kg	Chrysene	218-01-9	A	X	6.7	0.95	3.35	55	110	30	55	110	30					
8270 (MSPNA) (SIM level) Soil	ug/kg	Dibenzo(a,h)anthracene	53-70-3	A	X	6.7	1.2	3.35	40	125	30	40	125	30					
8270 (MSPNA) (SIM level) Soil	ug/kg	Fluoranthene	206-44-0	A	X	6.7	0.95	3.35	55	115	30	55	115	30					
8270 (MSPNA) (SIM level) Soil	ug/kg	Fluorene	86-73-7	A	X	6.7	0.73	3.35	50	110	30	50	110	30					
8270 (MSPNA) (SIM level) Soil	ug/kg	Indeno(1,2,3-cd)pyrene	193-39-5	A	X	6.7	1.4	3.35	40	120	30	40	120	30					
8270 (MSPNA) (SIM level) Soil	ug/kg	Naphthalene	91-20-3	A	X	6.7	1.3	3.35	40	105	30	40	105	30					
8270 (MSPNA) (SIM level) Soil	ug/kg	Phenanthrene	85-01-8	A	X	6.7	1.2	3.35	50	110	30	50	110	30					
8270 (MSPNA) (SIM level) Soil	ug/kg	Pyrene	129-00-0	A	X	6.7	1.2	3.35	45	125	30	45	125	30					
8270 (MSPNA) (SIM level) Soil	ug/kg	1-Fluoronaphthalene	321-38-0	S	X				0	0		0	0					35	110
8270 (MSPNA) (SIM level) Soil	ug/kg	Fluorene-d10	81103-79-9	S	X				0	0		0	0					45	120
8270 (MSPNA) (SIM level) Soil	ug/kg	Pyrene-d10	1718-52-1	S	X				0	0		0	0					50	150
8270 SVOAs Soil Appendix IX list	ug/kg	1,2,4,5-Tetrachlorobenzene	95-94-3	A		330	53	167											
8270 SVOAs Soil Appendix IX list	ug/kg	1,2,4-Trichlorobenzene	120-82-1	A	X	330	68	167	45	110	30	45	110						
8270 SVOAs Soil Appendix IX list	ug/kg	1,2-Dichlorobenzene	95-50-1	A	X	330	65	167	45	95	30	45	95						
8270 SVOAs Soil Appendix IX list	ug/kg	1,2-Diphenylhydrazine	122-66-7	A	X	330	94	167	50	105	30	50	105						
8270 SVOAs Soil Appendix IX list	ug/kg	1,3,5-Trinitrobenzene	99-35-4	A		330	36	167											
8270 SVOAs Soil Appendix IX list	ug/kg	1,3-Dichlorobenzene	541-73-1	A	X	330	73	167	40	100	30	40	100						
8270 SVOAs Soil Appendix IX list	ug/kg	1,3-Dinitrobenzene	99-65-0	A		330	43	167											
8270 SVOAs Soil Appendix IX list	ug/kg	1,4-Dichlorobenzene	106-46-7	A	X	330	80	167	35	105	30	35	105						
8270 SVOAs Soil Appendix IX list	ug/kg	1,4-Dioxane	123-91-1	A		330	110	167											
8270 SVOAs Soil Appendix IX list	ug/kg	1,4-Naphthoquinone	130-15-4	A		330	69	167											
8270 SVOAs Soil Appendix IX list	ug/kg	1,4-Phenylenediamine	106-50-3	A		670	49	335											
8270 SVOAs Soil Appendix IX list	ug/kg	1-Naphthylamine	134-32-7	A		330	34	167											
8270 SVOAs Soil Appendix IX list	ug/kg	2,3,4,6-Tetrachlorophenol	58-90-2	A		330	28	167											
8270 SVOAs Soil Appendix IX list	ug/kg	2,4,5-Trichlorophenol	95-95-4	A	X	330	69	167	50	110	30	50	110						
8270 SVOAs Soil Appendix IX list	ug/kg	2,4,6-Trichlorophenol	88-06-2	A	X	330	73	167	45	110	30	45	110						
8270 SVOAs Soil Appendix IX list	ug/kg	2,4-Dichlorophenol	120-83-2	A	X	330	84	167	45	110	30	45	110						
8270 SVOAs Soil Appendix IX list	ug/kg	2,4-Dimethylphenol	105-67-9	A	X	330	48	167	30	105	30	30	105						
8270 SVOAs Soil Appendix IX list	ug/kg	2,4-Dinitrophenol	51-28-5	A	X	670	40	335	15	130	30	15	130						
8270 SVOAs Soil Appendix IX list	ug/kg	2,4-Dinitrotoluene	121-14-2	A	X	330	66	167	50	115	30	50	115						
8270 SVOAs Soil Appendix IX list	ug/kg	2,6-Dichlorophenol	87-65-0	A		330	58	167											
8270 SVOAs Soil Appendix IX list	ug/kg	2,6-Dinitrotoluene	606-20-2	A	X	330	54	167	50	110	30	50	110						
8270 SVOAs Soil Appendix IX list	ug/kg	2-Acetylaminofluorene	53-96-3	A		330	13	167											
8270 SVOAs Soil Appendix IX list	ug/kg	2-Chloronaphthalene	91-58-7	A	X	330	76	167	45	105	30	45	105						
8270 SVOAs Soil Appendix IX list	ug/kg	2-Chlorophenol	95-57-8	A	X	330	75	167	45	105	30	45	105						
8270 SVOAs Soil Appendix IX list	ug/kg	2-Methylnaphthalene	91-57-6	A	X	330	82	167	45	105	30	45	105						
8270 SVOAs Soil Appendix IX list	ug/kg	2-Methylphenol	95-48-7	A	X	330	71	167	40	105	30	40	105						
8270 SVOAs Soil Appendix IX list	ug/kg	2-Naphthylamine	91-59-8	A		330	20	167											

8270 SVOAs Soil Appendix IX list	ug/kg	2-Nitroaniline	88-74-4	A	X	330	64	167	45	120	30	45	120					
8270 SVOAs Soil Appendix IX list	ug/kg	2-Nitrophenol	88-75-5	A	X	330	77	167	40	110	30	40	110					
8270 SVOAs Soil Appendix IX list	ug/kg	2-Picoline	109-06-8	A		330	88	167										
8270 SVOAs Soil Appendix IX list	ug/kg	3 & 4-Methylphenol	108-39-4/106-44-5	A	X	330	87	167	40	105	30	40	105					
8270 SVOAs Soil Appendix IX list	ug/kg	3,3'-Dichlorobenzidine	91-94-1	A	X	330	81	167	10	130	30	10	130					
8270 SVOAs Soil Appendix IX list	ug/kg	3,3'-Dimethylbenzidine	119-93-7	A		330	37	167										
8270 SVOAs Soil Appendix IX list	ug/kg	3-Methylcholanthrene	56-49-5	A		330	32	167										
8270 SVOAs Soil Appendix IX list	ug/kg	3-Nitroaniline	99-09-2	A	X	330	75	167	25	110	30	25	110					
8270 SVOAs Soil Appendix IX list	ug/kg	4,6-Dinitro-2-methylphenol	534-52-1	A	X	330	59	167	30	135	30	30	135					
8270 SVOAs Soil Appendix IX list	ug/kg	4-Aminobiphenyl	92-67-1	A		330	10	167										
8270 SVOAs Soil Appendix IX list	ug/kg	4-Bromophenyl-phenyl ether	101-55-3	A	X	330	74	167	45	115	30	45	115					
8270 SVOAs Soil Appendix IX list	ug/kg	4-Chloro-3-methylphenol	59-50-7	A	X	330	77	167	45	115	30	45	115					
8270 SVOAs Soil Appendix IX list	ug/kg	4-Chloroaniline	106-47-8	A	X	330	61	167	10	95	30	10	95					
8270 SVOAs Soil Appendix IX list	ug/kg	4-Chlorophenyl-phenylether	7005-72-3	A	X	330	84	167	45	110	30	45	110					
8270 SVOAs Soil Appendix IX list	ug/kg	4-Nitroaniline	100-01-6	A	X	330	81	167	35	115	30	35	115					
8270 SVOAs Soil Appendix IX list	ug/kg	4-Nitrophenol	100-02-7	A	X	330	130	167	15	140	30	15	140					
8270 SVOAs Soil Appendix IX list	ug/kg	4-Nitroquinoline-1-oxide	56-57-5	A		330	93	167										
8270 SVOAs Soil Appendix IX list	ug/kg	5-Nitro-o-toluidine	99-55-8	A		330	19	167										
8270 SVOAs Soil Appendix IX list	ug/kg	7,12-Dimethylbenz(a)anthracene	57-97-6	A		330	48	167										
8270 SVOAs Soil Appendix IX list	ug/kg	Acenaphthene	83-32-9	A	X	330	73	167	45	110	30	45	110					
8270 SVOAs Soil Appendix IX list	ug/kg	Acenaphthylene	208-96-8	A	X	330	73	167	45	105	30	45	105					
8270 SVOAs Soil Appendix IX list	ug/kg	Acetophenone	98-86-2	A		330	78	167										
8270 SVOAs Soil Appendix IX list	ug/kg	Aniline	62-53-3	A		330	19	167										
8270 SVOAs Soil Appendix IX list	ug/kg	Anthracene	120-12-7	A	X	330	69	167	55	105	30	55	105					
8270 SVOAs Soil Appendix IX list	ug/kg	Aramite A	140-57-8	A		670	64	335										
8270 SVOAs Soil Appendix IX list	ug/kg	Aramite B	140-57-8	A		670	50	335										
8270 SVOAs Soil Appendix IX list	ug/kg	Benzidine	92-87-5	A		330	26	167										
8270 SVOAs Soil Appendix IX list	ug/kg	Benzo(a)anthracene	56-55-3	A	X	330	66	167	50	110	30	50	110					
8270 SVOAs Soil Appendix IX list	ug/kg	Benzo(a)pyrene	50-32-8	A	X	330	68	167	50	110	30	50	110					
8270 SVOAs Soil Appendix IX list	ug/kg	Benzo(b)fluoranthene	205-99-2	A	X	330	76	167	45	115	30	45	115					
8270 SVOAs Soil Appendix IX list	ug/kg	Benzo(g,h,i)perylene	191-24-2	A	X	330	70	167	40	125	30	40	125					
8270 SVOAs Soil Appendix IX list	ug/kg	Benzo(k)fluoranthene	207-08-9	A	X	330	75	167	45	125	30	45	125					
8270 SVOAs Soil Appendix IX list	ug/kg	Benzoic acid	65-85-0	A	X	670	100	335	0	110	30	0	110					
8270 SVOAs Soil Appendix IX list	ug/kg	Benzyl alcohol	100-51-6	A	X	330	100	167	20	125	30	20	125					
8270 SVOAs Soil Appendix IX list	ug/kg	Bis(2-chloroethoxy)methane	111-91-1	A	X	330	80	167	45	110	30	45	110					
8270 SVOAs Soil Appendix IX list	ug/kg	Bis(2-Chloroethyl)ether	111-44-4	A	X	330	72	167	40	105	30	40	105					
8270 SVOAs Soil Appendix IX list	ug/kg	Bis(2-chloroisopropyl)ether	108-60-1	A	X	330	87	167	20	115	30	20	115					
8270 SVOAs Soil Appendix IX list	ug/kg	Bis(2-ethylhexyl)phthalate	117-81-7	A	X	330	58	167	45	125	30	45	125					
8270 SVOAs Soil Appendix IX list	ug/kg	Butylbenzylphthalate	85-68-7	A	X	330	66	167	50	125	30	50	125					
8270 SVOAs Soil Appendix IX list	ug/kg	Carbazole	86-74-8	A	X	330	74	167	45	115	30	45	115					
8270 SVOAs Soil Appendix IX list	ug/kg	Chlorobenzilate	510-15-6	A		330	13	167										
8270 SVOAs Soil Appendix IX list	ug/kg	Chrysene	218-01-9	A	X	330	66	167	55	110	30	55	110					
8270 SVOAs Soil Appendix IX list	ug/kg	cis-Isosafrole	17627-76-8	A		330	37	167										
8270 SVOAs Soil Appendix IX list	ug/kg	Diallate A	2303-16-4A	A		330	29	167										
8270 SVOAs Soil Appendix IX list	ug/kg	Diallate B	2303-16-4B	A		330	35	167										
8270 SVOAs Soil Appendix IX list	ug/kg	Dibenzo(a,h)anthracene	53-70-3	A	X	330	68	167	40	125	30	40	125					
8270 SVOAs Soil Appendix IX list	ug/kg	Dibenzofuran	132-64-9	A	X	330	74	167	50	105	30	50	105					
8270 SVOAs Soil Appendix IX list	ug/kg	Diethylphthalate	84-66-2	A	X	330	96	167	50	115	30	50	115					
8270 SVOAs Soil Appendix IX list	ug/kg	Dimethoate	60-51-5	A		330	67	167										
8270 SVOAs Soil Appendix IX list	ug/kg	Dimethylphthalate	131-11-3	A	X	330	79	167	50	110	30	50	110					
8270 SVOAs Soil Appendix IX list	ug/kg	Di-n-butylphthalate	84-74-2	A	X	330	100	167	55	110	30	55	110					
8270 SVOAs Soil Appendix IX list	ug/kg	Di-n-octylphthalate	117-84-0	A	X	330	70	167	40	130	30	40	130					
8270 SVOAs Soil Appendix IX list	ug/kg	Disulfoton	298-04-4	A		330	32	167										
8270 SVOAs Soil Appendix IX list	ug/kg	Ethyl methanesulfonate	62-50-0	A		330	27	167										
8270 SVOAs Soil Appendix IX list	ug/kg	Ethyl parathion	56-38-2	A		330	27	167										
8270 SVOAs Soil Appendix IX list	ug/kg	Famphur A	52-85-7A	A		670	100	335										
8270 SVOAs Soil Appendix IX list	ug/kg	Famphur B	52-85-7B	A		670	72	335										
8270 SVOAs Soil Appendix IX list	ug/kg	Fluoranthene	206-44-0	A	X	330	80	167	55	115	30	55	115					

8270 SVOAs Soil Appendix IX list	ug/kg	Fluorene	86-73-7	A	X	330	84	167	50	110	30	50	110						
8270 SVOAs Soil Appendix IX list	ug/kg	Hexachlorobenzene	118-74-1	A	X	330	65	167	45	120	30	45	120						
8270 SVOAs Soil Appendix IX list	ug/kg	Hexachlorobutadiene	87-68-3	A	X	330	56	167	40	115	30	40	115						
8270 SVOAs Soil Appendix IX list	ug/kg	Hexachlorocyclopentadiene	77-47-4	A	X	330	46	167	0	100	30	0	100						
8270 SVOAs Soil Appendix IX list	ug/kg	Hexachloroethane	67-72-1	A	X	330	67	167	35	110	30	35	110						
8270 SVOAs Soil Appendix IX list	ug/kg	Hexachloropropene	1888-71-7	A	X	330	56	167	0	0		0	0						
8270 SVOAs Soil Appendix IX list	ug/kg	Indeno(1,2,3-cd)pyrene	193-39-5	A	X	330	67	167	40	120	30	40	120						
8270 SVOAs Soil Appendix IX list	ug/kg	Isodrin	465-73-6	A		330	25	167											
8270 SVOAs Soil Appendix IX list	ug/kg	Isophorone	78-59-1	A	X	330	80	167	45	110	30	45	110						
8270 SVOAs Soil Appendix IX list	ug/kg	Kepone	143-50-0	A		330	86	167											
8270 SVOAs Soil Appendix IX list	ug/kg	Methapyrilene	91-80-5	A		330	30	167											
8270 SVOAs Soil Appendix IX list	ug/kg	Methyl methanesulfonate	66-27-3	A		330	30	167											
8270 SVOAs Soil Appendix IX list	ug/kg	Methyl parathion	298-00-0	A		330	41	167											
8270 SVOAs Soil Appendix IX list	ug/kg	Naphthalene	91-20-3	A	X	330	71	167	40	105	30	40	105						
8270 SVOAs Soil Appendix IX list	ug/kg	Nitrobenzene	98-95-3	A	X	330	67	167	40	115	30	40	115						
8270 SVOAs Soil Appendix IX list	ug/kg	N-Nitrosodiethylamine	55-18-5	A		330	97	167											
8270 SVOAs Soil Appendix IX list	ug/kg	N-Nitrosodimethylamine	62-75-9	A	X	330	65	167	20	115	30	20	115						
8270 SVOAs Soil Appendix IX list	ug/kg	N-Nitroso-di-n-butylamine	924-16-3	A		330	75	167											
8270 SVOAs Soil Appendix IX list	ug/kg	N-Nitroso-di-n-propylamine	621-64-7	A	X	330	94	167	40	115	30	40	115						
8270 SVOAs Soil Appendix IX list	ug/kg	N-Nitrosodiphenylamine	86-30-6	A	X	330	100	167	50	115	30	50	115						
8270 SVOAs Soil Appendix IX list	ug/kg	N-Nitrosomethylethylamine	10595-95-6	A		330	58	167											
8270 SVOAs Soil Appendix IX list	ug/kg	N-Nitrosomorpholine	59-89-2	A		330	80	167											
8270 SVOAs Soil Appendix IX list	ug/kg	N-Nitrosopiperidine	100-75-4	A		330	46	167											
8270 SVOAs Soil Appendix IX list	ug/kg	N-Nitrosopyrrolidine	930-55-2	A		330	40	167											
8270 SVOAs Soil Appendix IX list	ug/kg	O,O,O-Triethyl phosphorothioate	126-68-1	A		330	68	167											
8270 SVOAs Soil Appendix IX list	ug/kg	o-Toluidine	95-53-4	A		330	26	167											
8270 SVOAs Soil Appendix IX list	ug/kg	p-Dimethylaminoazobenzene	60-11-7	A		330	31	167											
8270 SVOAs Soil Appendix IX list	ug/kg	Pentachlorobenzene	608-93-5	A		330	45	167											
8270 SVOAs Soil Appendix IX list	ug/kg	Pentachloroethane	76-01-7	A		330	46	167											
8270 SVOAs Soil Appendix IX list	ug/kg	Pentachloronitrobenzene	82-68-8	A		330	21	167											
8270 SVOAs Soil Appendix IX list	ug/kg	Pentachlorophenol	87-86-5	A	X	330	72	167	25	120	30	25	120						
8270 SVOAs Soil Appendix IX list	ug/kg	Phenacetin	62-44-2	A		330	30	167											
8270 SVOAs Soil Appendix IX list	ug/kg	Phenanthrene	85-01-8	A	X	330	70	167	50	110	30	50	110						
8270 SVOAs Soil Appendix IX list	ug/kg	Phenol	108-95-2	A	X	330	240	167	40	100	30	40	100						
8270 SVOAs Soil Appendix IX list	ug/kg	Phentermine (a,a-Dimethylphenylethylamine)	122-09-8	A		670	58	335											
8270 SVOAs Soil Appendix IX list	ug/kg	Phorate	298-02-2	A		330	18	167											
8270 SVOAs Soil Appendix IX list	ug/kg	Pronamide	23950-58-5	A		330	20	167											
8270 SVOAs Soil Appendix IX list	ug/kg	Pyrene	129-00-0	A	X	330	73	167	45	125	30	45	125						
8270 SVOAs Soil Appendix IX list	ug/kg	Pyridine	110-86-1	A		330	69	167											
8270 SVOAs Soil Appendix IX list	ug/kg	Safrrole	94-59-7	A		330	46	167											
8270 SVOAs Soil Appendix IX list	ug/kg	Sulfotepp	3689-24-5	A		330	24	167											
8270 SVOAs Soil Appendix IX list	ug/kg	Thionazin	297-97-2	A		330	19	167											
8270 SVOAs Soil Appendix IX list	ug/kg	trans-Isosafrole	4043-71-4	A		330	47	167											
8270 SVOAs Soil Appendix IX list	ug/kg	2,4,6-Tribromophenol	118-79-6	S	X				0	0		0	0					35	125
8270 SVOAs Soil Appendix IX list	ug/kg	2-Fluorobiphenyl	321-60-8	S	X				0	0		0	0					45	105
8270 SVOAs Soil Appendix IX list	ug/kg	2-Fluorophenol	367-12-4	S	X				0	0		0	0					35	105
8270 SVOAs Soil Appendix IX list	ug/kg	Nitrobenzene-d5	4165-60-0	S	X				0	0		0	0					35	100
8270 SVOAs Soil Appendix IX list	ug/kg	Phenol-d5	4165-62-2	S	X				0	0		0	0					40	100
8270 SVOAs Soil Appendix IX list	ug/kg	Terphenyl-d14	1718-51-0	S	X				0	0		0	0					30	125
* Indicates that analyte is spiked.																			
Analyte Types: A - Target Analyte S - Surrogate																			
FORM LTL-PM-12.0																			

LAUCKS TESTING LABORATORIES, INC.

8260-1 VOAs Water DOD-QSM List - Target Control Limits

Method: Purgeable Organic Compounds by GC/MS
 Prep Schedule: 5030B-L (Water)
 Matrix: Water

Holding Time: 14/14 days
 Reporting Units: ug/L
 Has TICs: NO

Target Analyte	CAS#	Spiked?	PQL	MDL	LTL PQL	MS/MSD			BS/BSD		
						LCL	UCL	RPD	LCL	UCL	RPD
Dibromochloromethane	124-48-1	X	1	0.12	1	60	135	30	60	135	30
Dichlorodifluoromethane	75-71-8	X	1	0.19	1	30	155	30	30	155	30
Chloromethane	74-87-3	X	1	0.2	1	40	125	30	40	125	30
Vinyl chloride	75-01-4	X	1	0.27	1	50	145	30	50	145	30
Bromomethane	74-83-9	X	1	0.072	1	30	145	30	30	145	30
Chloroethane	75-00-3	X	1	0.27	1	60	135	30	60	135	30
Trichlorofluoromethane	75-69-4	X	1	0.24	1	60	145	30	60	145	30
1,1-Dichloroethene	75-35-4	X	1	0.12	1	70	130	30	70	130	30
Acetone	67-64-1	X	5	0.75	5	40	140	30	40	140	30
Carbon disulfide	75-15-0	X	1	0.16	1	35	160	30	35	160	30
Methylene chloride	75-09-2	X	1	1	1	55	140	30	55	140	30
Methyl tert-butyl ether	1634-04-4	X	1	0.16	1	65	125	30	65	125	30
trans-1,2-Dichloroethene	156-60-5	X	1	0.22	1	60	140	30	60	140	30
1,1-Dichloroethane	75-34-3	X	1	0.23	1	70	135	30	70	135	30
2,2-Dichloropropane	594-20-7	X	1	0.27	1	70	135	30	70	135	30
cis-1,2-Dichloroethene	156-59-2	X	1	0.32	1	70	125	30	70	125	30
2-Butanone	78-93-3	X	5	0.52	5	30	150	30	30	150	30
Bromochloromethane	74-97-5	X	1	0.34	1	65	130	30	65	130	30
Chloroform	67-66-3	X	1	0.15	1	65	135	30	65	135	30
1,1,1-Trichloroethane	71-55-6	X	1	0.2	1	65	130	30	65	130	30
Carbon tetrachloride	56-23-5	X	1	0.25	1	65	140	30	65	140	30
1,1-Dichloropropene	563-58-6	X	1	0.094	1	75	130	30	75	130	30
Benzene	71-43-2	X	1	0.12	1	80	120	30	80	120	30
1,2-Dichloroethane	107-06-2	X	1	0.074	1	70	130	30	70	130	30
Trichloroethene	79-01-6	X	1	0.22	1	70	125	30	70	125	30
1,2-Dichloropropane	78-87-5	X	1	0.16	1	75	125	30	75	125	30
Dibromomethane	74-95-3	X	1	0.18	1	75	125	30	75	125	30
Bromodichloromethane	75-27-4	X	1	0.11	1	75	120	30	75	120	30
cis-1,3-Dichloropropene	10061-01-5	X	1	0.086	1	70	130	30	70	130	30
4-Methyl-2-pentanone	108-10-1	X	5	0.32	5	60	135	30	60	135	30
Toluene	108-88-3	X	1	0.21	1	75	120	30	75	120	30
trans-1,3-Dichloropropene	10061-02-6	X	1	0.16	1	55	140	30	55	140	30
1,1,2-Trichloroethane	79-00-5	X	1	0.19	1	75	125	30	75	125	30
Tetrachloroethene	127-18-4	X	1	0.1	1	45	150	30	45	150	30
2-Hexanone	591-78-6	X	5	0.57	5	55	130	30	55	130	30
1,3-Dichloropropane	142-28-9	X	1	0.22	1	75	125	30	75	125	30
1,2-Dibromoethane	106-93-4	X	1	0.2	1	80	120	30	80	120	30
Chlorobenzene	108-90-7	X	1	0.12	1	80	120	30	80	120	30
Ethylbenzene	100-41-4	X	1	0.2	1	75	125	30	75	125	30
1,1,1,2-Tetrachloroethane	630-20-6	X	1	0.15	1	80	130	30	80	130	30
m,p-Xylene	179601-23-1	X	2	0.27	2	75	130	30	75	130	30
o-Xylene	95-47-6	X	1	0.15	1	80	120	30	80	120	30
Styrene	100-42-5	X	1	0.074	1	65	135	30	65	135	30
Bromoform	75-25-2	X	1	0.23	1	70	130	30	70	130	30
Isopropylbenzene	98-82-8	X	1	0.11	1	75	125	30	75	125	30
1,1,2,2-Tetrachloroethane	79-34-5	X	1	0.22	1	65	130	30	65	130	30
n-Propylbenzene	103-65-1	X	1	0.16	1	70	130	30	70	130	30
Bromobenzene	108-86-1	X	1	0.16	1	75	125	30	75	125	30
1,2,3-Trichloropropane	96-18-4	X	1	0.37	1	75	125	30	75	125	30
2-Chlorotoluene	95-49-8	X	1	0.098	1	75	125	30	75	125	30
1,3,5-Trimethylbenzene	108-67-8	X	1	0.16	1	75	130	30	75	130	30
4-Chlorotoluene	106-43-4	X	1	0.13	1	75	130	30	75	130	30

tert-Butylbenzene	98-06-6	X	1	0.11	1	70	130	30	70	130	30
1,2,4-Trimethylbenzene	95-63-6	X	1	0.086	1	75	130	30	75	130	30
sec-Butylbenzene	135-98-8	X	1	0.1	1	70	125	30	70	125	30
4-Isopropyltoluene	99-87-6	X	1	0.074	1	75	130	30	75	130	30
1,3-Dichlorobenzene	541-73-1	X	1	0.16	1	75	125	30	75	125	30
1,4-Dichlorobenzene	106-46-7	X	1	0.2	1	75	125	30	75	125	30
n-Butylbenzene	104-51-8	X	1	0.1	1	70	135	30	70	135	30
1,2-Dichlorobenzene	95-50-1	X	1	0.25	1	70	120	30	70	120	30
1,2-Dibromo-3-chloropropane	96-12-8	X	1	0.38	1	50	130	30	50	130	30
1,2,4-Trichlorobenzene	120-82-1	X	1	0.15	1	65	135	30	65	135	30
Hexachlorobutadiene	87-68-3	X	1	0.27	1	50	140	30	50	140	30
1,2,3-Trichlorobenzene	87-61-6	X	1	0.11	1	55	140	30	55	140	30
Naphthalene	91-20-3	X	1	0.1	1	55	140	30	55	140	30
Target Analyte	Blank	ICB	CCB	ICV	CCV	CRDL	CRDL Unit	Duplicate			
								RPD	Con.		
Dibromochloromethane	0.5			25	20						
Dichlorodifluoromethane	0.5			25	20						
Chloromethane	0.5			25	20						
Vinyl chloride	0.5			25	20						
Bromomethane	0.5			25	20						
Chloroethane	0.5			25	20						
Trichlorofluoromethane	0.5			25	20						
1,1-Dichloroethene	0.5			25	20						
Acetone	2.5			25	20						
Carbon disulfide	0.5			25	20						
Methylene chloride	0.5			25	20						
Methyl tert-butyl ether	0.5			25	20						
trans-1,2-Dichloroethene	0.5			25	20						
1,1-Dichloroethane	0.5			25	20						
2,2-Dichloropropane	0.5			25	20						
cis-1,2-Dichloroethene	0.5			25	20						
2-Butanone	2.5			25	20						
Bromochloromethane	0.5			25	20						
Chloroform	0.5			25	20						
1,1,1-Trichloroethane	0.5			25	20						
Carbon tetrachloride	0.5			25	20						
1,1-Dichloropropene	0.5			25	20						
Benzene	0.5			25	20						
1,2-Dichloroethane	0.5			25	20						
Trichloroethene	0.5			25	20						
1,2-Dichloropropane	0.5			25	20						
Dibromomethane	0.5			25	20						
Bromodichloromethane	0.5			25	20						
cis-1,3-Dichloropropene	0.5			25	20						
4-Methyl-2-pentanone	2.5			25	20						
Toluene	0.5			25	20						
trans-1,3-Dichloropropene	0.5			25	20						
1,1,2-Trichloroethane	0.5			25	20						
Tetrachloroethene	0.5			25	20						
2-Hexanone	2.5			25	20						
1,3-Dichloropropane	0.5			25	20						
1,2-Dibromoethane	0.5			25	20						
Chlorobenzene	0.5			25	20						
Ethylbenzene	0.5			25	20						
1,1,1,2-Tetrachloroethane	0.5			25	20						
m,p-Xylene	0.5			25	20						
o-Xylene	0.5			25	20						
Styrene	0.5			25	20						
Bromoform	0.5			25	20						
Isopropylbenzene	0.5			25	20						
1,1,2,2-Tetrachloroethane	0.5			25	20						
n-Propylbenzene	0.5			25	20						
Bromobenzene	0.5			25	20						

1,2,3-Trichloropropane	0.5		25	20				
2-Chlorotoluene	0.5		25	20				
1,3,5-Trimethylbenzene	0.5		25	20				
4-Chlorotoluene	0.5		25	20				
tert-Butylbenzene	0.5		25	20				
1,2,4-Trimethylbenzene	0.5		25	20				
sec-Butylbenzene	0.5		25	20				
4-Isopropyltoluene	0.5		25	20				
1,3-Dichlorobenzene	0.5		25	20				
1,4-Dichlorobenzene	0.5		25	20				
n-Butylbenzene	0.5		25	20				
1,2-Dichlorobenzene	0.5		25	20				
1,2-Dibromo-3-chloropropane	0.5		25	20				
1,2,4-Trichlorobenzene	0.5		25	20				
Hexachlorobutadiene	0.5		25	20				
1,2,3-Trichlorobenzene	0.5		25	20				
Naphthalene	0.5		25	20				

Surrogate Analyte	CAS#	Spiked?	Typical Limits		Special Limits	
			LCL	UCL	LCL	UCL
Dibromofluoromethane	1868-53-7	X	85	115		
1,2-Dichloroethane-d4	17060-07-0	X	70	120		
Toluene-d8	2037-26-5	X	85	120		
4-Bromofluorobenzene	460-00-4	X	75	120		

* Indicates the analyte is spiked.

These sample types use the special surrogate limits, none.

FORM LTL-PM-10.0

LAUCKS TESTING LABORATORIES, INC.

8082 PCBs Water (DOD-QSM) - Target Control Limits

Method: Polychlorinated Biphenyls by Gas Chromatography
 Prep Schedule: 3535 PCBs
 Matrix: Water

Holding Time: 7/40 days
 Reporting Units: ug/L
 Has TICs: NO

Target Analyte	CAS#	Spiked?	PQL	MDL	LTL PQL	MS/MSD			BS/BSD		
						LCL	UCL	RPD	LCL	UCL	RPD
Aroclor-1016	12674-11-2	X	0.5	0.043	0.5	25	145	20	25	145	
Aroclor-1221	11104-28-2	X	0.5	0.039	0.5	0	0		0	0	
Aroclor-1232	11141-16-5	X	0.5	0.084	0.5	0	0		0	0	
Aroclor-1242	53469-21-9	X	0.5	0.051	0.5	0	0		0	0	
Aroclor-1248	12672-29-6	X	0.5	0.086	0.5	0	0		0	0	
Aroclor-1254	11097-69-1	X	0.5	0.16	0.5	0	0		0	0	
Aroclor-1260	11096-82-5	X	0.5	0.045	0.5	30	145	21	30	145	

Target Analyte	Blank	ICB	CCB	ICV	CCV	CRDL	CRDL Unit	Duplicate	
								RPD	Con.
Aroclor-1016	0.25	0.25	0.25	20	20				
Aroclor-1221	0.25	0.25	0.25	20	20				
Aroclor-1232	0.25	0.25	0.25	20	20				
Aroclor-1242	0.25	0.25	0.25	20	20				
Aroclor-1248	0.25	0.25	0.25	20	20				
Aroclor-1254	0.25	0.25	0.25	20	20				
Aroclor-1260	0.25	0.25	0.25	20	20				

Surrogate Analyte	CAS#	Spiked?	Typical Limits		Special Limits	
			LCL	UCL	LCL	UCL
Decachlorobiphenyl	2051-24-3	X	40	135		
Tetrachloro-m-xylene	877-09-8	X	10	129		

* Indicates the analyte is spiked.

These sample types use the special surrogate limits, none.

FORM LTL-PM-10.0

LAUCKS TESTING LABORATORIES, INC.

6010B Metals Water (DOD-QSM) - Target Control Limits

Method: Metals by Inductively Coupled Plasma-Atomic Emission Spectrometry
 Prep Schedule: 3010A (Water) Total
 Matrix: Water

Holding Time: 180/180 days

Reporting Units: ug/L
 Has TICs: NO

Target Analyte	CAS#	Spiked?	PQL	MDL	LTL PQL	MS/MSD			BS/BSD		
						LCL	UCL	RPD	LCL	UCL	RPD
Aluminum	7429-90-5	X	500	22.3	500	80	120	20	80	120	20
Antimony	7440-36-0	X	60	3.01	60	80	120	20	80	120	20
Arsenic	7440-38-2	X	20	1.27	20	80	120	20	80	120	20
Barium	7440-39-3	X	100	0.845	200	80	120	20	80	120	20
Beryllium	7440-41-7	X	5	0.513	5	80	120	20	80	120	20
Cadmium	7440-43-9	X	5	1.07	5	80	120	20	80	120	20
Calcium	7440-70-2	X	5000	38.5	5000	80	120	20	80	120	20
Chromium	7440-47-3	X	10	0.306	10	80	120	20	80	120	20
Cobalt	7440-48-4	X	50	0.356	50	80	120	20	80	120	20
Copper	7440-50-8	X	25	0.535	25	80	120	20	80	120	20
Iron	7439-89-6	X	100	13.1	200	80	120	20	80	120	20
Lead	7439-92-1	X	10	1.78	10	80	120	20	80	120	20
Magnesium	7439-95-4	X	5000	4.14	5000	80	120	20	80	120	20
Manganese	7439-96-5	X	15	0.119	15	80	120	20	80	120	20
Molybdenum	7439-98-7	X	20	2.1	20	80	120	20	80	120	20
Nickel	7440-02-0	X	40	1.2	40	80	120	20	80	120	20
Potassium	7440-09-7	X	5000	9.31	5000	80	120	20	80	120	20
Selenium	7782-49-2	X	10	0.554	10	80	120	20	80	120	20
Silver	7440-22-4	X	10	0.422	10	80	120	20	80	120	20
Sodium	7440-23-5	X	5000	126	5000	80	120	20	80	120	20
Thallium	7440-28-0	X	20	5.94	20	80	120	20	80	120	20
Vanadium	7440-62-2	X	50	0.47	50	80	120	20	80	120	20
Zinc	7440-66-6	X	40	6.65	40	80	120	20	80	120	20

Target Analyte	Blank	ICB	CCB	ICV	CCV	CRDL	CRDL Unit	Duplicate	
								RPD	Con.
Aluminum	250	250	250	10	10	500	ug/L	20	2500
Antimony	30	30	30	10	10	60	ug/L	20	300
Arsenic	10	10	10	10	10	20	ug/L	20	100
Barium	50	50	50	10	10	200	ug/L	20	1000
Beryllium	2.5	2.5	2.5	10	10	5	ug/L	20	25
Cadmium	2.5	2.5	2.5	10	10	5	ug/L	20	25
Calcium	2500	2500	2500	10	10	5000	ug/L	20	25000
Chromium	5	5	5	10	10	10	ug/L	20	50
Cobalt	25	25	25	10	10	50	ug/L	20	250
Copper	12.5	12.5	12.5	10	10	25	ug/L	20	125
Iron	50	50	50	10	10	100	ug/L	20	1000
Lead	5	5	5	10	10	10	ug/L	20	50
Magnesium	2500	2500	2500	10	10	5000	ug/L	20	25000
Manganese	7.5	7.5	7.5	10	10	15	ug/L	20	75
Molybdenum	10	10	10	10	10	20	ug/L	20	100
Nickel	20	20	20	10	10	40	ug/L	20	200
Potassium	2500	2500	2500	10	10	5000	ug/L	20	25000
Selenium	5	5	5	10	10	10	ug/L	20	50
Silver	5	5	5	10	10	10	ug/L	20	50
Sodium	2500	2500	2500	10	10	5000	ug/L	20	25000
Thallium	10	10	10	10	10	20	ug/L	20	100
Vanadium	25	25	25	10	10	50	ug/L	20	250
Zinc	20	20	20	10	10	40	ug/L	20	200

Surrogate Analyte	CAS#	Spiked?	Typical Limits		Special Limits	
			LCL	UCL	LCL	UCL

* Indicates the analyte is spiked.

These sample types use the special surrogate limits, none.

LAUCKS TESTING LABORATORIES, INC.

6020 Metals Water (DOD-QSM) 3010A - Target Control Limits

Method: Metals by Inductively Coupled Plasma-Mass Spectrometry
 Prep Schedule: 3010A (Water) Total
 Matrix: Water

Holding Time: 180/180 days
 Reporting Units: ug/L
 Has TICs: NO

Target Analyte	CAS#	Spiked?	PQL	MDL	LTL PQL	MS/MSD			BS/BSD		
						LCL	UCL	RPD	LCL	UCL	RPD
Aluminum	7429-90-5	X	50	32	50	75	125	20	80	120	20
Antimony	7440-36-0	X	1	0.056	1	75	125	20	80	120	20
Arsenic	7440-38-2	X	1	0.1	1	75	125	20	80	120	20
Barium	7440-39-3	X	1	0.4	1	75	125	20	80	120	20
Beryllium	7440-41-7	X	1	0.043	1	75	125	20	80	120	20
Cadmium	7440-43-9	X	1	0.094	1	75	125	20	80	120	20
Calcium	7440-70-2	X	100	36	100	75	125	20	80	120	20
Chromium	7440-47-3	X	1	0.12	1	75	125	20	80	120	20
Cobalt	7440-48-4	X	1	0.028	1	75	125	20	80	120	20
Copper	7440-50-8	X	2	0.52	2	75	125	20	80	120	20
Iron	7439-89-6	X	50	20	50	75	125	20	80	120	20
Lead	7439-92-1	X	1	0.075	1	75	125	20	80	120	20
Magnesium	7439-95-4	X	100	4.4	100	75	125	20	80	120	20
Manganese	7439-96-5	X	5	0.44	5	75	125	20	80	120	20
Molybdenum	7439-98-7	X	1	0.56	1	75	125	20	80	120	20
Nickel	7440-02-0	X	1	0.11	1	75	125	20	80	120	20
Potassium	7440-09-7	X	100	11	100	75	125	20	80	120	20
Selenium	7782-49-2	X	1	0.11	1	75	125	20	80	120	20
Silver	7440-22-4	X	1	0.085	1	75	125	20	80	120	20
Sodium	7440-23-5	X	100	38	100	75	125	20	80	120	20
Thallium	7440-28-0	X	1	0.044	1	75	125	20	80	120	20
Vanadium	7440-62-2	X	2	0.049	2	75	125	20	80	120	20
Zinc	7440-66-6	X	10	1.8	10	75	125	20	80	120	20

Target Analyte	Blank	ICB	CCB	ICV	CCV	CRDL	CRDL Unit	Duplicate	
								RPD	Con.
Aluminum	25	25	25	10	10	50	ug/L	20	250
Antimony	0.5	0.5	0.5	10	10	1	ug/L	20	5
Arsenic	0.5	0.5	0.5	10	10	1	ug/L	20	5
Barium	0.5	0.5	0.5	10	10	1	ug/L	20	5
Beryllium	0.5	0.5	0.5	10	10	1	ug/L	20	5
Cadmium	0.5	0.5	0.5	10	10	1	ug/L	20	5
Calcium	50	50	50	10	10	100	ug/L	20	500
Chromium	0.5	0.5	0.5	10	10	1	ug/L	20	5
Cobalt	0.5	0.5	0.5	10	10	1	ug/L	20	5
Copper	1	1	1	10	10	2	ug/L	20	10
Iron	25	25	25	10	10	50	ug/L	20	250
Lead	0.5	0.5	0.5	10	10	1	ug/L	20	5
Magnesium	50	50	50	10	10	100	ug/L	20	500
Manganese	2.5	2.5	2.5	10	10	5	ug/L	20	25
Molybdenum	0.5	0.5	0.5	10	10	1	ug/L	20	5
Nickel	0.5	0.5	0.5	10	10	1	ug/L	20	5
Potassium	50	50	50	10	10	100	ug/L	20	500
Selenium	0.5	0.5	0.5	10	10	1	ug/L	20	5
Silver	0.5	0.5	0.5	10	10	1	ug/L	20	5
Sodium	50	50	50	10	10	500	ug/L	20	500
Thallium	0.5	0.5	0.5	10	10	1	ug/L	20	5
Vanadium	1	1	1	10	10	2	ug/L	20	10
Zinc	5	5	5	10	10	10	ug/L	20	50

Surrogate Analyte	CAS#	Spiked?	Typical Limits		Special Limits	
			LCL	UCL	LCL	UCL

* Indicates the analyte is spiked.

These sample types use the special surrogate limits, none.

LAUCKS TESTING LABORATORIES, INC.**7470 Mercury Water (DOD-QSM) - Target Control Limits**

Method: 7470A Mercury
 Prep Schedule: 7470PR (Water) Total
 Matrix: Water

Holding Time: 28/28 days
 Reporting Units: ug/L
 Has TICs: NO

Target Analyte	CAS#	Spiked?	PQL	MDL	LTL PQL	MS/MSD			BS/BSD		
						LCL	UCL	RPD	LCL	UCL	RPD
Mercury	7439-97-6	X	0.2	0.018	0.2	80	120	20	80	120	20
Target Analyte	Blank	ICB	CCB	ICV	CCV	CRDL	CRDL Unit	Duplicate			
								RPD	Con.		
Mercury	0.1	0.1	0.1	10	20	0.2	ug/L	20	1		

Surrogate Analyte	CAS#	Spiked?	Typical Limits		Special Limits	
			LCL	UCL	LCL	UCL

* Indicates the analyte is spiked.

These sample types use the special surrogate limits, none.

FORM LTL-PM-10.0

Attachment C
Standard Operating Procedures



TITLE: BOREHOLE INSTALLATION

CATEGORY: GEO 4.7

REVISED: April 1998

STANDARD OPERATING PROCEDURE

BOREHOLE INSTALLATION

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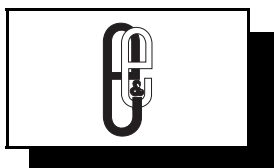
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1. Introduction

1.1 Scope

This document outlines the procedures to be followed by the subcontract driller for the collection of subsurface soil samples from boreholes. It has been developed to supplement standard operating procedures currently used by Ecology and Environment, Inc.

1.2 Objectives

Most subsurface investigations require the drilling of boreholes for one or more purposes: collection of soil samples for lithologic logging and laboratory testing; lithologic and hydrogeologic characterization using borehole geophysical logging; and installation of piezometers or monitoring wells. Drilling methods are selected based on availability and cost; suitability for the type of geologic materials at a site (unconsolidated or consolidated); and potential effects on sample integrity (influence by drilling fluids and potential for cross-contamination between aquifers).

A wide variety of drilling methods have been developed that could be suitable for one or more of the purposes described above. Table 1 summarizes information on 18 drilling methods. The hollow-stem auger is by far the most commonly used method for well installation in unconsolidated deposits. Air rotary is the most commonly used method for well installation in consolidated formations. Table 2 provides information on the relative performance of 11 of the drilling methods listed in Table 1 for different types of geologic formations.

Subsurface soil samples are collected from boreholes for chemical and physical analysis and to aid in the definition and tracking of contaminants in the soil. The subsurface soil samples may be either composite or discrete, and either disturbed or undisturbed. The type of sample to be collected depends on the drilling technique and the purpose of the investigation.

2. Drilling and Sampling Techniques

The most accurate method for obtaining information on the characteristics of unconsolidated deposits is to collect representative samples of the soil at measured depths and at intervals that will provide a complete lithologic profile of the soils. For most boreholes, subsurface soil samples are collected continuously, at 5-foot intervals, or at every change in formation material.


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Table 1
SUMMARY INFORMATION ON DRILLING METHODS

Drill Method	Casing/Open Hole	Do Fluids Affect Chemical?	Core Samples?
Hollow-Stem Auger	Open Hole	Usually No	Possible
Open-Hole Rotary Methods			
Direct Air Rotary with Bit	Open Hole	Yes	Possible
Direct Air Rotary with Downhole Hammer	Open Hole	Yes	Possible
Direct Mud Rotary	Open Hole	Yes	Possible
Reverse Rotary (no casing)	Open Hole	Yes	Possible
Cable Tool	Either	Usually No	Possible
Rotary Drill-Through Methods			
Rotary Casing Driver	Casing	Yes	Possible
Dual Rotary Advancement	Casing	Yes	Possible
Reverse Circulation Methods			
Reverse Dual Wall Rotary	Casing	Yes	Possible
Reverse Dual Wall Percussion	Casing	Yes	Possible
Hydraulic Percussion	Casing	Yes	Possible
Downhole Casing Advancers	Casing	Yes	Possible
Jet Percussion	Casing	Possible	Possible
Jetting	Open Hole	Possible	No
Solid-Stem Auger	Open Hole	No	Possible
Bucket Auger	Open Hole	No	Possible
Rotary Diamond	Open Hole	Possible	Yes
Directional Drilling	Either ^a	Possible	Possible ^b
Sonic Drilling	Either	Possible	Yes
Driven Wells	Either	No	No
Cone Penetration	Open Hole	No	Possible ^c

^a

EC rig uses casing advancement; other methods may involve open-hole advancement.

^b

Sampling with a device resembling a split spoon may be possible with some directional rigs.

^c

Geoprobe has developed a core sampler for use with a CPT rig.

2.1 Disturbed and Undisturbed Overburden Samples

Soil samples from unconsolidated deposits can be collected as disturbed or undisturbed soil samples. Disturbed soil samples are produced by the action of the hollow-stem auger (HSA) and are called drill cuttings. The components of an HSA are shown in Figure 1. Disturbed samples are not representative of the formations penetrated because of the possible sorting and grinding of the cuttings while being carried to the surface. In general, disturbed samples do not contain detailed lithologic information, and the depth that the soil is encountered is less precise.

Undisturbed soil samples are collected in a variety of sampling devices, including the split-barrel sampler (see Figure 2), the Laskey sampler (see Figure 3), and the Shelby tube sampler.



Table 2
RELATIVE PERFORMANCE OF DIFFERENT DRILLING METHODS
IN VARIOUS TYPES OF GEOLOGIC FORMATIONS
(Rate of Penetration^a)

Type of Formation	Cable Tool	Direct Rotary (with fluids)	Direct Rotary (with air)	Direct Rotary (Down-the-hole air hammer)	Direct Rotary (Drill-through casing hammer)	Reverse Rotary (with fluids)	Reverse Rotary (Dual Wall)	Hydraulic Percussion	Jetting	Driven	Auger
Dune sand	2	5	NR	NR	6	5 ^b	6	5	5	3	1
Loose sand and gravel	2	5	NR	NR	6	5 ^b	6	5	5	3	1
Quicksand	2	5	NR	NR	6	5 ^b	6	5	5	NR	1
Loose boulders in alluvial fans or glacial drift	3-2	2-1	NR	NR	5	2-1	4	1	1	NR	1
Clay and silt	3	5	NR	NR	5	5	5	3	3	NR	3
Firm shale	5	5	NR	NR	5	5	5	3	NR	NR	2
Sticky shale	3	5	NR	NR	5	3	5	3	NR	NR	2
Brittle shale	5	5	NR	NR	5	5	5	3	NR	NR	NA
Sandstone—poorly cemented	3	4	NR	NR	NA	4	5	4	NR	NR	NA
Sandstone—well cemented	3	3	5	NR	NA	3	5	3	NR	NR	NA
Chert nodules	5	3	3	NR	NA	3	3	5	NR	NR	NA
Limestone	5	5	5	6	NA	5	5	5	NR	NR	NA
Limestone with chert nodules	5	3	5	6	NA	3	3	5	NR	NR	NA
Limestone with small cracks or fractures	5	3	5	6	NA	2	5	5	NR	NR	NA
Limestone, cavernous	5	3-1	2	5	NA	1	5	1	NR	NR	NA

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Table 2
RELATIVE PERFORMANCE OF DIFFERENT DRILLING METHODS
IN VARIOUS TYPES OF GEOLOGIC FORMATIONS
(Rate of Penetration^a)

Type of Formation	Cable Tool	Direct Rotary (with fluids)	Direct Rotary (with air)	Direct Rotary (Down-the-hole-air hammer)	Direct Rotary (Drill-through casing hammer)	Reverse Rotary (with fluids)	Reverse Rotary (Dual Wall)	Hydraulic Percussion	Jetting	Driven	Auger
Dolomite	5	5	5	6	NA	5	5	5	NR	NR	NA
Basalts, thin layers in sedimentary rocks	5	3	5	6	NA	3	5	5	NR	NR	NA
Basalts—thick layers	3	3	4	5	NA	3	4	3	NR	NR	NA
Basalts—highly fractured (lost circulation zones)	3	1	3	3	NA	1	4	1	NR	NR	NA
Metamorphic rocks	3	3	4	5	NA	3	4	3	NR	NR	NA
Granite	3	3	5	5	NA	3	4	3	NR	NR	NA

^a Rate of Penetration:

- 1 = Impossible
- 2 = Difficult
- 3 = Slow
- 4 = Medium
- 5 = Rapid
- 6 = Very rapid

^b Assuming sufficient hydrostatic pressure is available to contain active sand (under high confining pressures).

Key:

NA = Not applicable.
 NR = Not recommended.

Source: Driscoll 1986.

CATEGORY:

GEO 4.7

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April 1998

TITLE:

BOREHOLE INSTALLATION

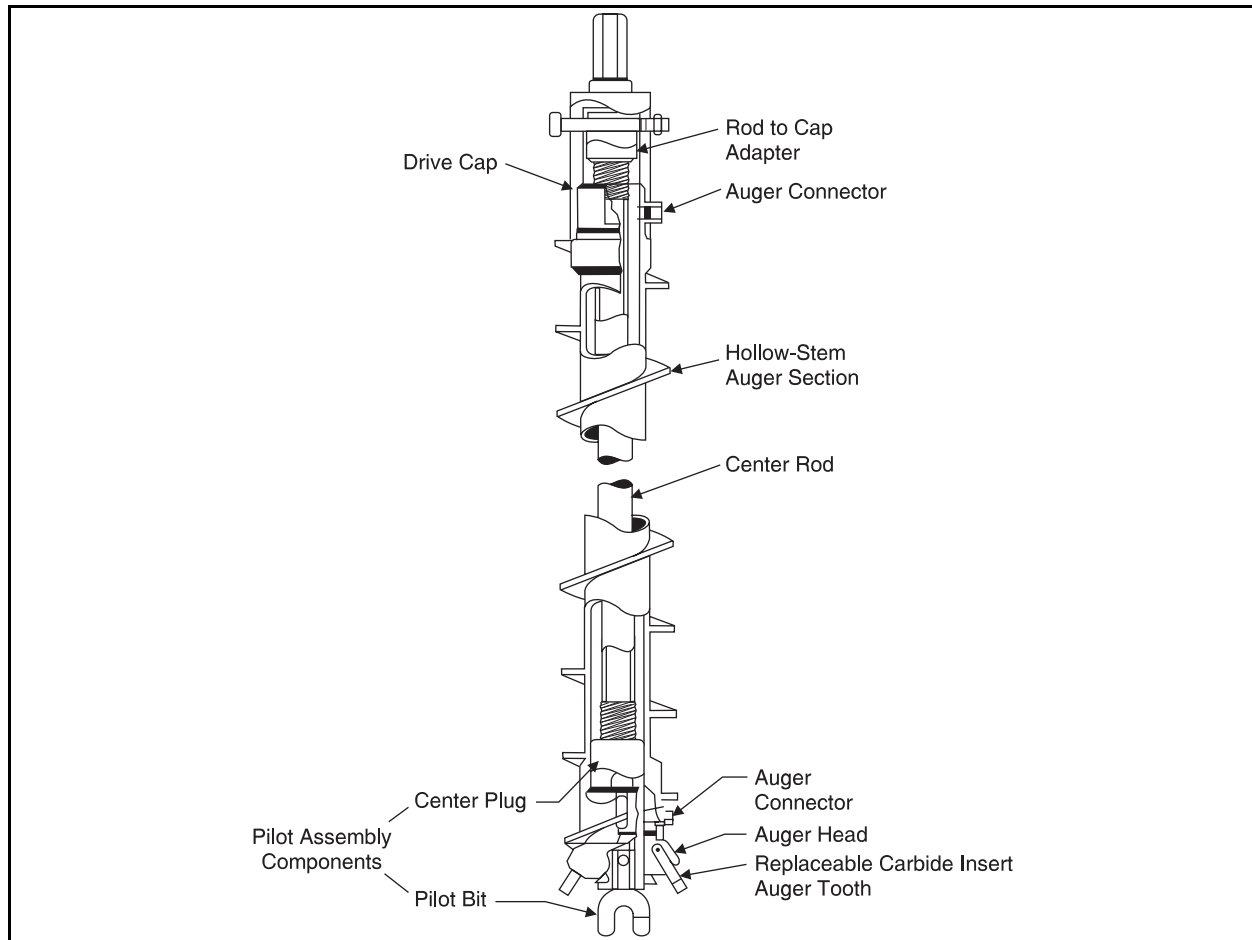
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Figure 1 Typical Components of a Hollow-Stem Auger

The collection of undisturbed samples ensures the preservation of detailed lithologic information, such as the degree of consolidation, sorting, bedding, etc., and a more accurate estimation of sample depth.

2.2 Composite and Discrete Overburden Samples

Composite samples are prepared from aliquots of discrete samples. They are useful for obtaining a representative sample from a subsurface interval for analytical purposes. However, composite samples are inadequate for lithologic purposes.

Discrete samples are obtained from a specific depth and are useful when detailed analytical information about the overburden soils is required. Analysis of discrete overburden soil samples provides accurate information on the depth of contamination.



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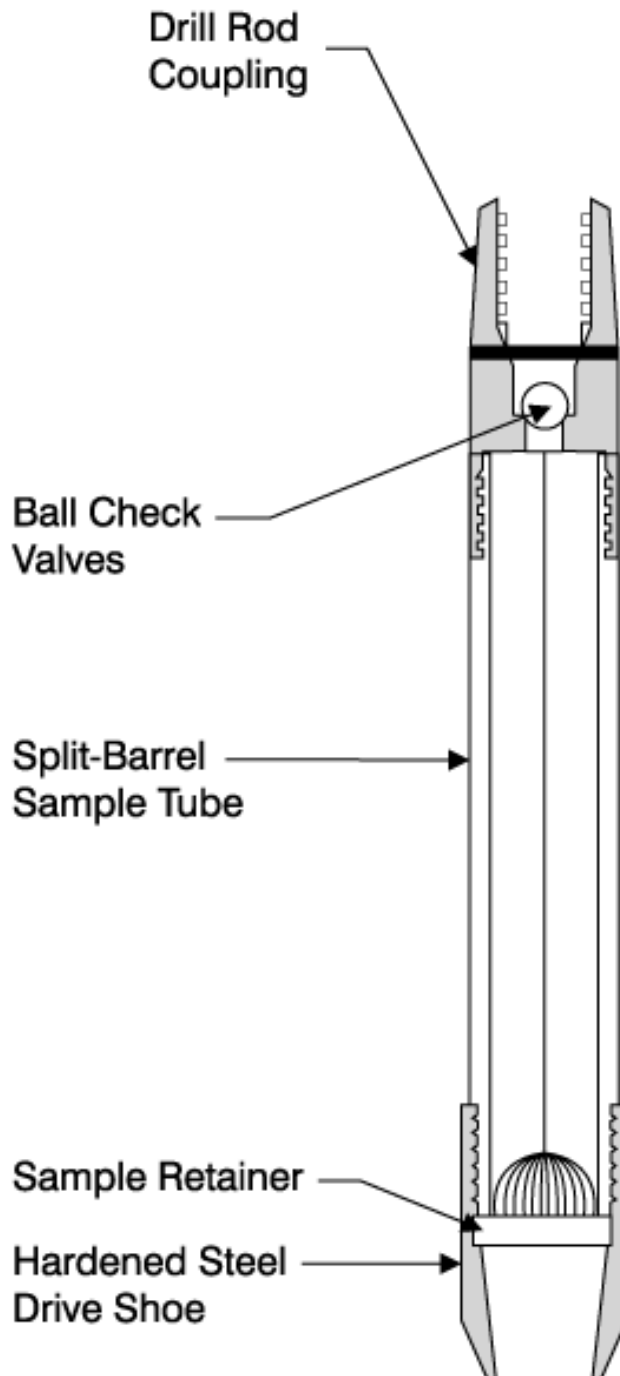


Figure 2 Split-Spoon or Split-Barrel Sampler



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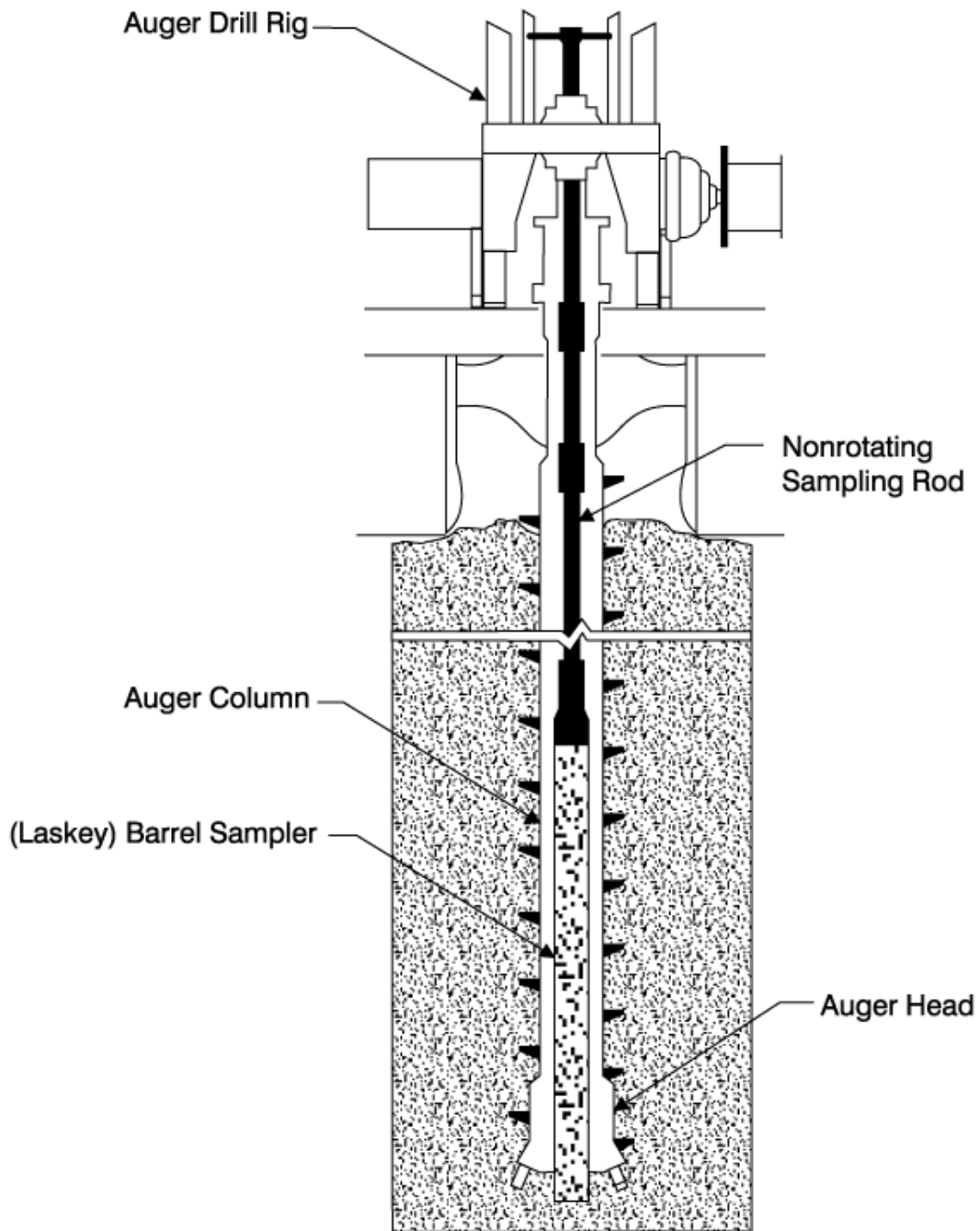


Figure 3 Continuous Sampling Tube System (Laskey)

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3. Borehole Installation

3.1 Inspection and Cleaning of Sampling Equipment

Proper cleaning of the drill rig, downhole equipment, and sampling equipment upon arriving at the site and between drilling locations is necessary to minimize the potential introduction of contaminants into the overburden samples. Care should be taken to steam clean the drill rig and all other equipment before they are used. The drill rig should be checked repeatedly for oil and hydraulic fluid leaks. These precautions are essential to ensure that trace contaminants from the drilling process are not introduced to the samples.

3.2 Hollow-Stem Auger Drilling

A hollow-stem auger column simultaneously rotates and axially advances using a mechanically or hydraulically powered drill rig. The hollow stem of the auger allows use of various methods for continuous or intermittent sampling of subsurface soils. Riser and screen for monitoring wells can be placed in the hollow stem when the desired depth has been reached, and filter pack and grouting emplaced as the auger is gradually withdrawn from the hole. Use of different diameter augers allows use of casings to isolate near-surface contamination and continuation of drilling with a smaller-diameter auger. HSA flights are manufactured in 5-foot lengths and have various inside diameters (IDs) ranging from 2.25-inch ID to 10.25-inch ID. E & E uses 4.25-inch-ID and 6.25-inch-ID HSAs to install boreholes.

If a split-barrel soil sampler is used to collect unconsolidated deposited soil samples, a center plug of the same diameter as the HSAs and a section of drilling rod is placed inside the lead flight. The HSAs are advanced through the unconsolidated deposit to the first sampling interval, and the center plug is then removed from the HSAs. A precleaned split-barrel soil sampler is attached to the end of the drilling rod and lowered into the HSAs. A safety hammer is attached to the top of the drilling rod, and the split-barrel soil sampler driven into the undisturbed soil to a depth of 2 feet. The split-barrel soil sampler is retrieved and opened to remove the soil sample. The center plug is replaced in the HSAs, and another flight of HSAs is attached to the top of the flight already in the ground. The process is repeated until bedrock is encountered or the project depth is reached.

A Laskey soil sampler is used to collect a 5-foot continuous soil sample while the HSAs are turning. The Laskey soil sampler is used instead of a center plug in 4.25-inch HSAs, and the head of the sampler leads the HSAs by 2 to 6 inches. At the completion of a 5-foot run of HSAs, the Laskey soil sampler is recovered and opened in a manner similar to a split-barrel sampler. Following sample collection and decontamination of the Laskey soil sampler, the sampler is replaced inside the HSAs, and another flight of HSAs is attached to the top of the flight already in the ground.

A Shelby tube sampler is used to collect undisturbed overburden soil samples in a manner similar to a split-barrel soil sampler. Shelby tubes come in a variety of widths and lengths. E & E uses 3-inch-ID and 5-inch-ID Shelby tubes that are 18 and 30 inches long. Once

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the HSAs have reached the top of the interval to be sampled, the drilling rods holding the center plug are withdrawn from the HSAs, the Shelby tube is attached to the end of the drilling rod, and the Shelby tube is lowered into the HSAs. The Shelby tube is pushed out the bottom of the HSAs to the prescribed depth, and the tube is retrieved. The Shelby tube is not opened in the field, but is shipped to the laboratory. The process is repeated until bedrock is encountered or the project depth is reached.

3.3 Direct Air Rotary and Downhole Hammer

The basic rig setup for air rotary with a tri-cone or roller-cone bit is similar to direct mud rotary, except that the circulation medium is air rather than water or mud. Compressed air is circulated down through the drill rods to cool the bit and carry cuttings up the hole to the surface. A cyclone separator slows the air velocity and allows the cuttings to fall into a container. A down-the-hole hammer, which operates with a pounding action as it rotates, replaces the roller-cone bit.

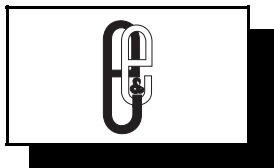
3.4 Other Methods

Several methods are available for obtaining shallow subsurface soil samples (less than 10 feet) without using a drill rig:

- **Hand Augers.** These are useful for obtaining samples from shallow depths in unconsolidated formations. Samples are collected from the auger bucket at specific intervals.
- **Power Augers.** These are usually hand augers powered by a gasoline engine. The samples are collected from the auger flight as the tool is turned.
- **Backhoes.** Backhoes are relatively inexpensive and can excavate a slit trench up to 12 feet deep very quickly. Samples can be obtained by attaching a Shelby tube to the bucket or by sampling directly out of the bucket.

4. Borehole Abandonment

Borehole abandonment is necessary to eliminate potential physical hazards, prevent groundwater contamination, conserve aquifer yield and hydrostatic head, and prevent intermixing of subsurface water. After the necessary unconsolidated soil samples or consolidated core samples have been collected from the borehole, the HSAs are removed from the borehole and the HSA flights cleaned. A cement/bentonite grout should be tremied into the borehole to the



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surface. The grout should consist of potable water, bentonite powder, and Type I Portland cement, with 94 lbs. of cement and 5 lbs. of bentonite per 6.5 gallons of water.

5. Disposal of Drill Cuttings and Decontamination Water

5.1 Containerization of Drill Cuttings and Decontamination Liquids

Drill cuttings must be handled as outlined in the work plan for the site. In most instances, the drill cuttings are classified as hazardous waste under the Resource Conservation and Recovery Act (RCRA) and must be placed in 55-gallon steel drums approved by the U.S. Department of Transportation (DOT) pending analysis. The drums of drill cuttings must be properly labeled and marked with the source of the drill cuttings (e.g., "MW-2") prior to being staged. Decontamination fluids must also be placed in DOT-approved 55-gallon steel drums pending analysis. The drums of decontamination water must be properly labeled and marked with the source of the fluids and the date that the drum was filled prior to being staged.

5.2 Disposal of Drill Cuttings and Decontamination Water

Upon receipt of the analytical results, the drill cuttings and decontamination water can be properly classified. It is the responsibility of the property owner and/or client to arrange for the disposal of the drill cuttings and fluids at an approved facility.

6. Borehole Abandonment Reports

6.1 Borehole Abandonment Records Sheets

At the completion of the borehole installation, a Borehole Abandonment Record will be completed by the driller. The borehole abandonment record summarizes details of the borehole construction. An example Borehole Abandonment Record is attached as Figure 4.

6.2 Well Completion Cost Sheet

At the completion of the fieldwork, a cost sheet outlining the costs associated with the installation of the borehole will be completed. An example of a cost sheet is attached as Figure 5.



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7. References

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BOREHOLE/WELL ABANDONMENT RECORD

Project Name: _____ Project Number: _____
Client: _____ Location: _____
Start Date: ____/____/____ Completion Date: ____/____/____
Drilling Method: _____ Driller: _____
Borehole/Well Location: _____

Borehole/Well Designation: _____ Open Depth: _____ feet

Casing Information (Wells): Depth: _____ feet
Composition: PVC SS
Size: _____ inches

Drilled and Samples Depths: _____ feet/_____ feet

Items Left in Hole: _____

Type of Grout Used: _____

Quantity of Grout: Initial: _____ bags Date: ____/____/____

Subsequent: _____ bags Date: ____/____/____

Water/Mud Level Prior to Abandonment: _____ BGS Date: ____/____/____

Remaining Casing Above Ground Surface: Height: _____ feet

Size: _____ inches

Composition: _____

SHOW MAJOR FEATURES OF
BOX & LOCATE WELL →
WITH AN X
SOURCES OF DRILLING WATER
1.
2.
3.

DRAW A SKETCH BELOW SHOWING LOCATION OF WELL IN
RELATION TO NEARBY TOWNS AND ROADS AND GIVE
DISTANCE FROM WELL TO NEAREST ROAD JUNCTION

N



Figure 4 Borehole/Well Abandonment Record

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**COST SHEET FOR DRILLING, SAMPLING, AND INSTALLATION
OF 2-INCH ID MONITORING WELLS**

Client: _____

Job Number: _____ Prepared by: _____ Date: _____

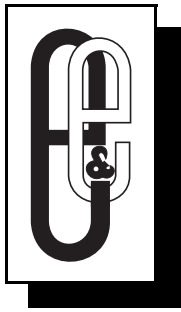
Bid Item	Description	Unit Price	Estimated Quantities	Totals
1	Mobilization and Demobilization	\$4.00/mile or \$400.00	_____ miles	_____
2	Soil Boring (4.25" HSA)	\$12.00/LF	_____ LF	_____
2a	Soil Boring (6.25" HSA)	\$15.00/LF	_____ LF	_____
3	Well Installation	\$13.00/LF	_____ LF	_____
4	Split-Spoon Samples Every 5 Feet	\$20.00/ sample	_____ samples	_____
5	Split-Spoon Samples Continuous	\$10.00/foot	_____ feet	_____
6	Rock Coring/Concrete Coring	\$30.00/LF	_____ LF	_____
7	Core Boxes	\$40.00 ea	_____	_____
8	2-Inch-ID PVC Riser	\$3.75/LF	_____ LF	_____
9	2-Inch-ID PVC Screen (0.010")	\$6.75/LF	_____ LF	_____
10	8-Inch-ID Carbon Steel Casing	\$24.00/LF	_____ LF	_____
10a	4-Inch-ID Carbon Steel Casing	\$19.00/LF	_____ LF	_____
11	Plugs and Caps, PVC	\$4.44 ea	_____	_____
11a	Plugs and Caps, SS	\$30.00 ea	_____	_____

Figure 5 Well Completion Cost Estimate Sheet (Page 1 of 2)

**TITLE:****BOREHOLE INSTALLATION****CATEGORY:****GEO 4.7****REVISED:****April 1998**

Bid Item	Description	Unit Price	Estimated Quantities	Totals
12	Sand	\$6.00/LF	_____ LF	_____
13	Bentonite (Pellets)	\$15.00/LF	_____ LF	_____
14	Cement (Boreholes)	\$5.00/LF	_____ LF	_____
15	Cement/Bentonite (Wells) (10%) Grout	\$5.00/LF	_____ LF	_____
16	Shelby Tube, 3" by 30"	\$100.00 ea	_____	_____
17	Well Development (1.5 Hours/Well)	\$150.00	_____ wells	_____
18	Decontamination Time	\$100.00/HR	_____ HR	_____
19	Furnish and Installed Flush Well Protector	\$500.00/well	_____ wells	_____
20	Reaming to 5 $\frac{7}{8}$ Inches	\$26.00/LF	_____ LF	_____
21	Bentonite Seal Between Auger and Bed-rock	\$36.00/LF	_____ LF	_____
22	Decon Pad Construction	\$100.00/pad	_____ pads	_____
23	Standby Time	\$85.00/HR	_____ HR	_____
24	Well Abandonment (2.5 hours/well)	\$250.00 ea	_____ wells	_____
This cost sheet represents a summary of the estimated drilling costs associated with the installation of monitoring wells and/or soil borings at the location noted above. Any questions should be brought to the attention of E & E as soon as possible.			Subtotal	_____
			Discount	_____
			Total	_____

Figure 5 Well Completion Cost Estimate Sheet (Page 2 of 2)



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STANDARD OPERATING PROCEDURE

BOREHOLE SAMPLING

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1. Introduction

1.1 Scope

This document presents an in-depth discussion of the techniques used to obtain subsurface soil samples from boreholes.

1.2 Objectives

Most subsurface investigations require the drilling of boreholes for one or more purposes, including: collection of soil samples for lithologic logging and laboratory testing; lithologic and hydrogeologic characterization using borehole geophysical logging; and installation of piezometers or monitoring wells. Drilling methods are selected based on availability and cost; suitability for the type of geologic materials at a site (unconsolidated or consolidated); and possible effects on sample integrity (potential influence of drilling fluids and for cross contamination between aquifers).

A wide variety of drilling methods have been developed that may be suitable for one or more of the purposes described above. Table 1 summarizes information on 21 drilling methods. The hollow-stem auger (HSA) is the most commonly used method for well installation in unconsolidated deposits. Air rotary drilling is probably the most commonly used method for well installation in consolidated formations. Table 2 provides information on the relative performance of 11 of the drilling methods listed in Table 1 for different types of geologic formations.

Subsurface soil samples are collected from boreholes for chemical and physical analysis, and to aid in the definition and tracking of contaminants in the soil. The type subsurface soil sample may be either undisturbed or disturbed, and either composite or discrete. The type of sample to be collected depends on the purpose of the investigation and the drilling technique.

2. Drilling and Sampling Techniques

The most accurate method for obtaining information on the characteristics of unconsolidated deposits is to collect representative samples of soil at measured depths and at intervals that will provide a complete stratigraphic and lithologic profiles of soils and bedrock, respectively. For most boreholes, subsurface soil samples are collected continuously, at 2- or 5-foot intervals, or at every change in the formation.


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Table 1			
SUMMARY INFORMATION ON DRILLING METHODS			
Drill Method	Casing/Open Hole	Fluids Affect Chem.?	Core Samples?
Open-Hole Rotary Methods			
Hollow-Stem Auger	Open hole	Usually no fluids	Possible
Direct Air Rotary with Bit	Open hole	Yes	Possible
Direct Air Rotary with Downhole hammer	Open hole	Yes	Possible
Direct Mud Rotary	Open hole	Yes	Possible
Reverse Rotary (no casing)	Open hole	Yes	Possible
Cable Tool	Either	Usually no	Possible
Rotary Drill-Through Methods			
Rotary Casing Driver	Casing	Yes	Possible
Dual Rotary Advancement	Casing	Yes	Possible
Reverse Circulation Methods			
Reverse Dual Wall Rotary	Casing	Yes	Possible
Reverse Dual Wall Percussion	Casing	Yes	Possible
Hydraulic Percussion	Casing	Yes	Possible
Downhole Casing Advancers	Casing	Yes	Possible
Jet Percussion	Casing	Possible	Possible
Jetting	Open hole	Possible	No
Solid-Stem Auger	Open hole	No	Possible
Bucket Auger	Open hole	No	Possible
Rotary Diamond	Open hole	Possible	Yes
Directional Drilling	Either ^a	Possible	Possible ^a
Sonic Drilling	Either	Possible	Yes
Driven Wells	Either	No	No
Cone Penetration	Open hole	No	Possible ^b

^a Sampling with a device resembling a split spoon may be possible with some directional rigs.

^b Geoprobe has developed a core sampler for use with a cone penetrometer type (CPT) rig.

Key:

Shading indicates most commonly used methods for monitoring well installation.

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Table 2**RELATIVE PERFORMANCE OF DIFFERENT DRILLING METHODS
IN VARIOUS TYPES OF GEOLOGIC FORMATIONS**

Type of Formation	Cable Tool	Direct Rotary (with fluids)	Direct Rotary (with air)	Direct Rotary (Down-the-hole-air hammer)	Direct Rotary (Drill-through casing hammer)	Reverse Rotary (with fluids)	Reverse Rotary (Dual Wall)	Hydraulic Percussion	Jetting	Driven	Auger
Dune sand	2	5	NR	NR	6	5 ^a	6	5	5	3	1
Loose sand and gravel	2	3-5	NR	NR	6	5 ^a	6	5	5	3	1
Quicksand	2	5	NR	NR	6	5 ^a	6	5	5	NR	1
Loose boulders in alluvial fans or glacial drift	3-2	2-1	NR	NR	5	2-1	4	1	1	NR	1
Clay and silt	3	5	NR	NR	5	5	5	3	3	NR	3
Firm shale	5	5	NR	NR	5	5	5	3	NR	NR	2
Sticky shale	3	5	NR	NR	5	3	5	3	NR	NR	2
Brittle shale	5	5	NR	NR	5	5	5	3	NR	NR	NA
Sandstone—poorly cemented	3	4	NR	NR	NA	4	5	4	NR	NR	NA
Sandstone—well cemented	3	3	5	NR	NA	3	5	3	NR	NR	NA
Chert nodules	5	3	3	NR	NA	3	3	5	NR	NR	NA
Limestone	5	5	5	6	NA	5	5	5	NR	NR	NA
Limestone with chert nodules	5	3	5	6	NA	3	3	5	NR	NR	NA
Limestone with small cracks or fractures	5	3	5	6	NA	2	5	5	NR	NR	NA
Limestone, cavernous	5	3-1	2	5	NA	1	5	1	NR	NR	NA



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Table 2

**RELATIVE PERFORMANCE OF DIFFERENT DRILLING METHODS
IN VARIOUS TYPES OF GEOLOGIC FORMATIONS**

Type of Formation	Cable Tool	Direct Rotary (with fluids)	Direct Rotary (with air)	Direct Rotary (Down-the-hole-air hammer)	Direct Rotary (Drill-through casing hammer)	Reverse Rotary (with fluids)	Reverse Rotary (Dual Wall)	Hydraulic Percussion	Jetting	Driven	Auger
Dolomite	5	5	5	6	NA	5	5	5	NR	NR	NA
Basalts, thin layers in sedimentary rocks	5	3	5	6	NA	3	5	5	NR	NR	NA
Basalts—thick layers	3	3	4	5	NA	3	4	3	NR	NR	NA
Basalts—highly fractured (lost circulation zones)	3	1	3	3	NA	1	4	1	NR	NR	NA
Metamorphic rocks	3	3	4	5	NA	3	4	3	NR	NR	NA
Granite	3	3	5	5	NA	3	4	3	NR	NR	NA

4^a Assuming sufficient hydrostatic pressure is available to contain active sand (under high confining pressures).

Rate of Penetration:

- 1 = Impossible
- 2 = Difficult
- 3 = Slow
- 4 = Medium
- 5 = Rapid
- 6 = Very rapid

Key:

NA = Not applicable.
NR = Not recommended.

Source: Driscoll (1986).

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2.1 Disturbed and Undisturbed Samples

Soil samples from unconsolidated deposits can be collected as disturbed or undisturbed soil samples. Disturbed soil samples are produced by HSA drilling and are therefore referred to as drill cuttings. The components of a HSA are shown in Figure 1. Disturbed samples are not representative of the formations penetrated because of the possible sorting and grinding of the cuttings while being carried to the surface. In general, disturbed samples do not contain detailed lithologic information, and the depth at which the soil is encountered is not precisely known. Undisturbed soil samples are collected by a variety of sampling devices, including the split-barrel sampler (see Figure 2), the Laskey sampler (see Figure 3), and the Shelby tube sampler. The collection of undisturbed samples helps to ensure the preservation of detailed lithologic information such as the degree of consolidation, sorting, bedding, etc., and provides a more accurate determination of sample depth.

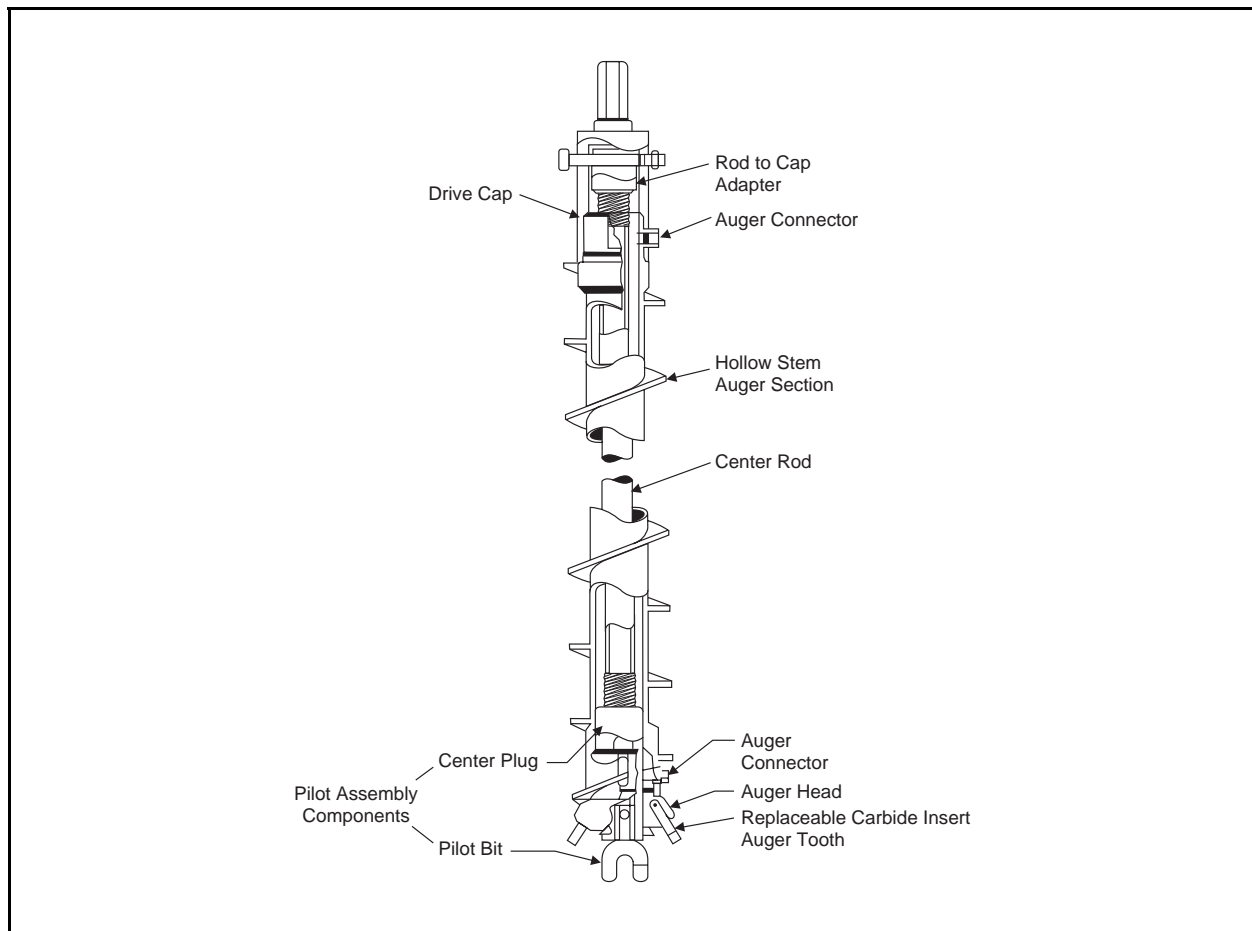


Figure 1 Typical Components of a Hollow-Stem Auger



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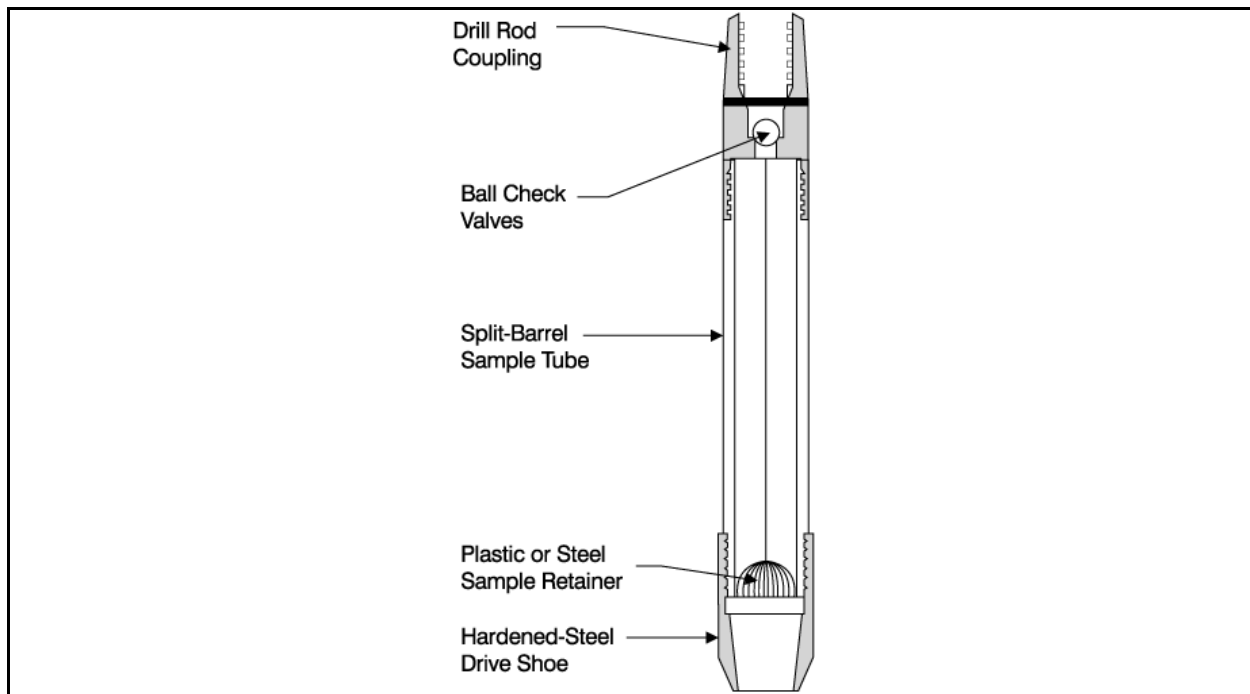


Figure 2 Split-Spoon or Split-Barrel Sampler

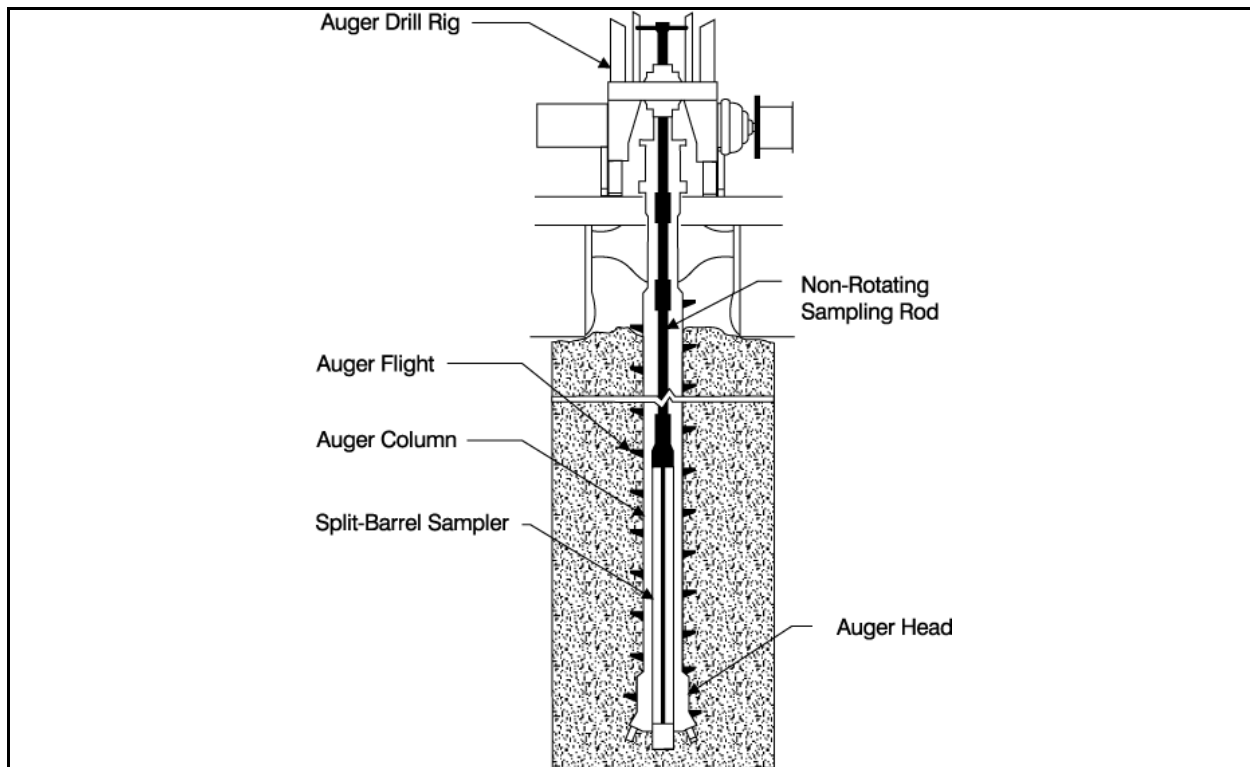


Figure 3 Continuous Sampling Tube System

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2.2 Discrete and Composite Samples

Discrete samples are obtained from a specific depth and are used when detailed analytical information about overburden soils is required. Analysis of discrete unconsolidated soil samples provides more accurate information on the depth of contamination.

Composite samples are prepared from aliquots of discrete samples. They are used for obtaining a representative sample from a subsurface interval for analytical purposes. Composite samples are not appropriate for use in stratigraphic description.

3. Borehole Drilling

3.1 Inspection and Cleaning of Sampling Equipment

Proper cleaning, including steam-cleaning, of the drill rig, down-hole equipment, and sampling equipment, should be performed upon arriving at the site and between drilling locations. This is necessary to minimize the potential introduction of contaminants into unconsolidated soil samples. The drill rig should also be checked repeatedly for oil and hydraulic fluid leaks. These precautions are essential to ensure that contaminants from the drilling process are not introduced into the samples. If specified in the site-specific work plan (SSWP), all non-disposable sampling equipment may need to be decontaminated according to specific procedure referenced in the SSWP.

3.2 Hollow-Stem Auger Drilling

A HSA column simultaneously rotates and axially advances by a mechanically or hydraulically powered drill rig. The hollow stem of the auger allows the use of various methods for continuous or intermittent sampling of subsurface soils. HSA columns are manufactured in 5-foot lengths and have inside diameters (IDs) ranging from 2.25-inch ID to 10.25-inch ID. Drilling with augers of different diameters makes possible the use of casings to isolate near-surface contamination while drilling continues with a smaller-diameter auger. In addition, the riser and screen for monitoring wells can be placed in the HSAs when the desired depth of drilling has been reached, and filter pack and grouting can be emplaced as the HSAs are gradually withdrawn from the hole.

If a split-barrel soil sampler is used to collect samples from unconsolidated deposits, a center plug with the same diameter as the HSAs, and a section of drilling rod are placed inside the lead flight. The HSAs are advanced through the unconsolidated deposit to the first sampling interval, and the center plug is then removed from the HSA. A precleaned split-barrel soil sampler is attached to the end of the drilling rod and lowered into the HSAs. A safety hammer is attached to the top of the drilling rod and the split-barrel soil sampler is driven into the undisturbed soil in an increment of 2 feet. The split-barrel soil sampler is then raised and opened to remove the soil sample. The center plug is then re-placed into the HSAs, and another HSA

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flight is attached to the top of the flight already in the ground. The process is repeated until bedrock is encountered or the project depth is reached.

A Laskey soil sampler is used to collect a continuous 5-foot soil sample while the HSAs are turning. The Laskey soil sampler is used instead of a center plug in 4.25-inch HSAs, and the head of the sampler is advanced ahead of the HSAs by 2 to 6 inches. Upon completion of a 5-foot run of HSAs, the Laskey soil sampler is recovered and opened in a manner similar to a split-barrel sampler. Following sample collection and decontamination of the Laskey soil sampler, the sampler is re-placed into the HSAs, and another flight of HSAs is attached to the top of the flight already in the ground.

A Shelby tube sampler is used to collect samples of undisturbed overburden usually for collection of geotechnical samples. Shelby tubes are available in a variety of diameters and lengths. The most common Shelby tubes are 3 to 5 inches I.D. and 18 to 30 inches long. Once the HSAs have reached the top of the interval to be sampled, the drilling rods holding the center plug are withdrawn from the HSAs. The Shelby tube is then attached to the end of the drilling rod and lowered into the HSAs. The Shelby tube is "pushed" out the bottom of the HSAs to the prescribed depth and then retrieved. The tube is not opened in the field; the ends are sealed (with wax) and it is shipped to the laboratory intact. The process is repeated until bedrock is encountered or the project depth is reached.

3.3 Direct Air Rotary, Mud Rotary, and Downhole Hammer Drilling

The basic rig setups for air or mud rotary with tri-cone or roller-cone bit are similar, except for the circulation medium used. Compressed air or mud is circulated down through the drill rods to cool the bit and carry cuttings up the hole to the surface. For air rotary drilling, a cyclone separator is used to slow the air velocity and allow the cuttings to fall into a container. A down-the-hole hammer, which operates with a percussive (pounding) action as it rotates, is used for air rotary drilling. For mud rotary drilling, a tri-cone roller bit is used.

3.4 Cable Tool Drilling

Cable tool drilling rigs operate by repeatedly lifting and dropping a heavy string of drilling tools attached to a cable into the borehole. Consolidated rock is broken or crushed into small fragments, and unconsolidated material is loosened by the drill bit. The reciprocating action is caused by attaching the cable to an eccentric walking or spudding beam that also serves to mix the crushed or loosened particles with water to form a slurry at the bottom of the borehole. Periodically, the drilling string is removed and the slurry is removed by a sand pump or bailer. In unconsolidated formations, a casing is driven into the ground to keep the hole open.

A sample of cable tool cuttings should include more than one bailer load of material to provide a composite sample that is reasonably representative of the sampling interval. This is particularly important when sampling sand and gravel formations. The cable tool drilling method is not as common a method for installing monitoring wells as it once was.



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3.5 Other Methods for Collecting Shallow Subsurface Soil Samples

Several methods are available for obtaining shallow subsurface soil samples (less than 10 feet) without using a drill rig.

- **Hand Augers.** These are useful for obtaining samples from shallow depths in unconsolidated formations. Samples are collected from a bucket auger advanced by hand through shallow depth intervals.
- **Power Augers.** These are usually hand augers powered by a gasoline engine. Disturbed soil samples are collected from the auger flight as the tool is turned.
- **Backhoes.** Backhoes are relatively inexpensive and can excavate a slit trench up to 12 feet deep very quickly. Samples can be obtained by attaching a Shelby tube to the bucket or by collecting samples directly out of the bucket.
- **Geoprobe.** This is a truck- or van-mounted hydraulic unit which pushes or hammers a small diameter probe into shallow, unconsolidated soils. The unit can be used to collect samples of subsurface soils, soil gas, or groundwater.

4. Borehole Abandonment

Borehole abandonment is necessary to eliminate potential physical hazards, to prevent groundwater contamination, to conserve aquifer yield and hydrostatic head, and to prevent intermixing of subsurface water. After the necessary unconsolidated soil samples or consolidated core samples have been collected from the borehole, the HSAs are removed from the borehole and the HSA flights are cleaned and appropriately decontaminated. A cement/bentonite grout should be tremied into the borehole to the surface. The grout should consist of potable water, bentonite powder, and Type I portland cement, with 94 pounds of cement and 5 pounds of bentonite per 6.5 gallons of water. In certain areas, specific borehole or well abandonment methods are specified in the associated environment regulations and these methods must be adhered to.

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5. Disposal of Drill Cuttings and Decon Liquids

5.1 Containerization of Drill Cuttings and Decon Liquids

Drill cuttings must be handled as outlined in the work plan for the site. In some instances, the drill cuttings are classified as hazardous waste under the Resource Conservation and Recovery Act (RCRA) and must be placed in U.S. Department of Transportation (DOT)-approved 55-gallon steel drums pending analysis. The drums of drill cuttings must be properly labeled and marked with the contents, date, and source of the drill cuttings (e.g., "MW-2") prior to being staged.

Decon fluids may also be placed in DOT-approved 55-gallon steel drums pending analysis. The drums of decon liquids must be properly labeled and marked with the type and source of the fluids and the date the drum was filled prior to being staged.

In instances when field monitoring for the presence of contaminants in soil and water is performed, approval for not containerizing investigation-derived soil and water may be approved by the local regulatory agency. This approval must be obtained prior to the commencement of the field investigation.

5.2 Disposal of Drill Cuttings and Decon Liquids

Upon receipt of the analytical results, the drill cuttings and decon liquids can be properly classified. It is the responsibility of the property owner and/or client to arrange for the disposal of the drill cuttings and fluids at an approved facility.

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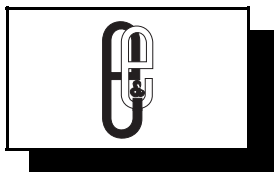
STANDARD OPERATING PROCEDURE

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1. Summary

This Standard Operating Procedure (SOP) establishes requirements for the entry of information into logbooks to ensure that E & E field activities are properly documented. The project manager (PM) and the field team leader (FTL) are responsible for ensuring that logbook entries provide sufficient information for the completion of an accurate and detailed description of field operations and meets the requirements of the contract or technical direction document (TDD).

This SOP describes logbook entry requirements for all types of projects, specifies the format that should be used, and provides examples. Some flexibility exists when implementing the SOP because different types of projects require different data collection efforts. This SOP does not address site safety logbook requirements or geotechnical logbook entries.

2. Purpose

Complete and accurate logbook entries are important for several reasons: to ensure that data collection associated with field activities is sufficient to support the successful completion of the project; to provide sufficient information so that someone not associated with the project can independently reconstruct the field activities at a later date; to maintain quality control (QC) throughout the project; to document changes to or deviations from the work plan; to fulfill administrative needs of the project; and to support potential legal proceedings associated with a specific project.

2.1 Adequate Field Information/Quality Control

QC procedures for data collection begin with the complete and systematic documentation of all persons, duties, observations, activities, and decisions that take place during field activities. It is especially important to fully document any deviations from the contract, project scope, work plans, sampling plans, site safety plans, quality assurance (QA) procedures, personnel, and responsibilities, as well as the reasons for the deviations.

Prior to entering the field, the project manager must indicate to the field team what pertinent information must be collected during field activity in order to meet the desired objectives of the data collection effort. The PM is responsible for reviewing the adequacy of the project logbooks both during and following completion of field activities, and is also responsible for meeting with the field team members to discuss any findings and to direct activities to correct any deficiencies, as appropriate. The PM also has the responsibility of ensuring that the logbooks become part of the project or TDD file.

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2.2 Work Plan Changes/Deviation

The logbook is the document that describes implementation of the work plan and other appropriate contract documents and provides the basis for the project reports. It must include detailed descriptions of any and all deviation from the work plan and the circumstances that necessitate such changes. These changes will be reviewed for compliance with data quality objectives and include:

- Changes in procedures agreed to in the project planning stages;
- Any conditions that prevent the completion of the field effort, or that result in additional fieldwork must be noted (i.e., weather delays, government actions, physical obstructions, personnel/equipment problems, etc.). Persons from whom permission was obtained to make such changes must be clearly documented.
- Any modifications requested by the client or client's representative that are contradictory to the contract or outside of the existing scope of work must be documented in detail because the cost of the project could be affected by such modifications.

2.3 Evidentiary Documentation

Field activity documentation can become evidence in civil and/or criminal judicial proceedings, as well as in administrative hearings. Field logbooks serve this purpose. Accordingly, such documentation is subject to judicial or administrative review. More importantly, it is subject to the review of an opposing counsel who will attempt to discredit its evidentiary value.

The National Enforcement Investigation Center (NEIC) and the United States Environmental Protection Agency (EPA) have prepared documents outlining their documentation needs for legal proceedings. These guidelines indicate the importance of accurate and clear documentation of information obtained during the inspections, investigations, and evaluations of uncontrolled hazardous waste sites. Consequently, attention to detail must be applied by E & E personnel to all field documentation efforts for all E & E projects. Project personnel must document where, when, how, and from whom any vital project information was obtained. This information is necessary to establish a proper foundation for admissible evidence.

3. Guidelines

Logbooks should contain a summary of any meeting or discussion held with a client or with any federal, state, or other regulatory agency that was on site during the field activities. The

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logbook should also describe any other personnel that appear on site, such as representatives of a potential responsible party (PRP).

The logbook can be used to support cost recovery activities. Data concerning site conditions must be recorded before the response activity or the passage of time eliminates or alters those conditions. Logbooks are also used to identify, locate, label, and track samples and their final disposition. In addition, data recorded in the logbook will assist in the interpretation of the analytical results.

Logbooks are subject to internal and external audits. Therefore, the recorded information should be consistent with and capable of substantiating other site documentation such as time cards, expense reports, chain-of-custody forms, shipping papers, and invoices from suppliers and subcontractors, etc. Logbooks also act as an important means of reconstructing events should other field documents such as data collection forms become lost or destroyed. Therefore, all mission-essential information should be duplicated in the logbook.

3.1 General Instructions

The following general guidelines must be used for all logbooks:

- At a minimum, one separate field activity logbook must be maintained for each project or TDD.
- All logbooks must be bound and contain consecutively numbered pages.
- No pages may be removed for any reason, even if they are partially mutilated or illegible.
- All field activities must be recorded in the site logbook (e.g., meetings, sampling, surveys, etc.).
- All information must be **printed legibly** in the logbook using waterproof ink, preferably black. If weather conditions do not permit this (i.e., if it is too cold or too wet to write with ink), another medium, such as pencil, may be used. The reason that waterproof ink was not used should be specifically noted in the logbook.
- The language used in the logbook should be objective, factual, and free of personal feelings or terminology that might prove inappropriate.
- Entries should be made in chronological order. Contemporaneous entries are always preferred because recollections fade or change over time. Observations that cannot be recorded during field activities should be recorded as soon after as possible. If logbook entries



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are not made during field activities, the time of the activity/observation and the time that it is recorded should be noted.

- The first entry for each day will be made on a new, previously blank page.
- Each page should be dated and each entry should include the time that the activity occurred based on the 24-hour clock (e.g., 0900 for 9 a.m., 2100 for 9 p.m.).
- At the completion of the field activity, the logbook must be returned to the permanent project or TDD file.

3.2 Format

The information presented below is not meant to be all-inclusive. Each project manager is responsible for determining the specific information requirements associated with a field activity logbook. If someone other than the Project Manager is keeping the logbook, the Project Manager is responsible to convey to that individual, prior to the start of fieldwork, specific instructions on what type of information is required to be entered into the logbook. Information requirements will vary according to the nature and scope of the project. (Refer to Appendix A for an example of a completed logbook.)

Title Page

The logbook title page should contain the following items:

- Site name,
- Location,
- TDD No. or Job No.,
- PAN (an EPA site/task identification number), if applicable,
- SSID No. (Site ID number-assigned under CERCLA), if applicable,
- Start/Finish date, and
- Book ___ of ___.



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First Page

The following items should appear on the first page of the logbook prior to daily field activity entries:

- TDD No. or Job No.,
- Date,
- Summary of proposed work (Reference work plan and contract documents, as appropriate),
- Weather conditions,
- Team members and duties, and
- Time work began and time of arrival (24-hour clock).

Successive Pages

In addition to specific activity entries and observations, the following items should appear on every logbook page:

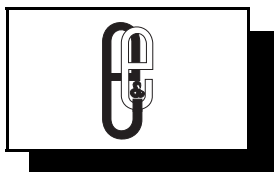
- Date,
- TDD or Job No., and
- Signature (bottom of each page). If more than one person makes entries into the logbook, each person should sign next to his or her entry.

Last Page

In addition to specific activity entries and observations and the items that should appear on each successive page, the last page of the logbook should contain a brief paragraph that summarizes the work that was completed in the field. This summary can become especially important later on if more or less work was accomplished during the duration of the field activity.

3.3 Corrections

If corrections are necessary, they must be made by drawing a single line through the original entry in such a manner that it can still be read. *Do not erase or render an incorrect notation illegible.* The corrected entry should be written beside the incorrect entry, and the



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correction must be initialed and dated. Most corrected errors will require a footnote explaining the correction.

4. Documentation

Although the requirements and content of the field logbook will vary according to the site and the tasks to be performed, the following information should be included in every logbook:

4.1 Prior to Fieldwork

Summary of Proposed Work

The first paragraph of **each** daily entry should summarize the work to be performed on that day. For example:

"Collect soil and groundwater samples from previously installed wells and ship samples to Analytical Services Center (ASC). Discuss removal with site owner."

The first paragraph becomes especially important later when discussing work plan deviations or explaining why more or less work was accomplished for that day.

Personnel

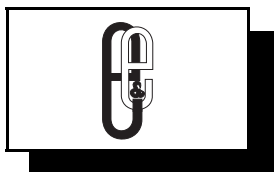
Each person to be involved in activities for the day, his/her respective role (sampler, health and safety, etc.), and the agency he/she represents should be noted in the logbook.

On-Site Weather Conditions

Weather conditions may have an impact on the work to be performed or the amount of time required to perform the proposed work; therefore, all weather on-site weather conditions should be noted, including temperatures, wind speed and direction, precipitation, etc., and updated as necessary. Similarly, any events that are impacted by weather conditions should be noted in the logbook.

Site Safety Meeting

Although minutes should be recorded for all site safety meetings under separate cover, the logbook should briefly summarize the site safety meeting and any specific site conditions and resultant site safety concerns.



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4.2 Site Sketch

A site sketch should be prepared on the first day of field activities to indicate prominent site and environmental features. The sketch should be made either to scale or by noting the approximate distances between site feature. Area-specific sketches should be prepared as work is undertaken in such areas, and updated sketches should be drawn as work progresses.

Site Features

Examples of features to be noted on the site sketch include the following:

- Structures such as buildings or building debris;
- Drainage ditches or pathways, swales, and intermittent streams (include direction of overland runoff flow and direction of stream flow);
- Access roads, site boundaries, and utility locations;
- Decontamination and staging areas;
- Adjacent property data: the type of property that borders the site, information pertaining to ownership, and available addressees; and
- North arrow.

Changes in Site Conditions

Any deviation from previous site sketches or drawings presented in the work plan, and any changes that have occurred since the last site visit must be noted. Differences to be noted include the following:

- Demolished buildings;
- Changes to access routes;
- Damage to wells or equipment, or changes to the amount of such equipment believed to be on site,
- Changes resulting from vandalism;
- Destruction of reference points;

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- Changes resulting from environmental events or natural disasters; and
- Locations of excavations, waste piles, investigation-derived waste (IDW), drum staging areas, etc.

In short, *any* site condition that varies from the conditions described in the work plan should be noted.

4.3 Monitoring Equipment and Activities

Any monitoring equipment used during field activities should be documented in the logbook. Information to be noted includes:

- The type of equipment with model and serial numbers. (HNu, OVA, etc.);
- The frequency at which monitoring is performed;
- Calibration results and the frequency at which the equipment is calibrated or tested;
- Background readings;
- Any elevated or unusual readings; and
- Any equipment malfunctions.

It is particularly important to note elevated or unusual equipment readings because they could have an impact on personal protection levels or the activities to be performed on site. If a change in the proposed work or protection levels occurs, it should be clearly noted in the logbook.

4.4 Sample Collection Activities

Because it represents the first step in an accurate chain-of-custody procedure, field sampling documentation must be complete. The following items should be documented in the logbook:

Sample Collection Procedures

The following items pertaining to sample collection procedures should be included in the logbook:

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- Any pre-sampling activities (i.e., well purging and the number of volumes purged before sample collection);
- Results of the pre-sampling activities (i.e., pH/conductivity/temperature readings for well water, results of hazard categorization testing, etc.);
- Any environmental conditions that make sample collection difficult or impossible (i.e., dry or flooded drainage paths, inclement weather conditions, etc.); and
- Any deviation from the work plan (i.e., additional samples and the reason for their collection, alternate sample locations, etc.).

Sample Information

The following information regarding sample data should be recorded in the logbook:

- Sample number and station location including relationship to permanent reference point(s);
- Name(s) of sampler(s);
- Sample description and any field screening results;
- Sample matrix and number of aliquots if a composite sample;
- Preservatives used, recipient laboratory, and requested analyses;
- QA/QC samples; and
- Shipping paper (airbill) numbers, chain-of-custody form numbers, and jar lot numbers.

Investigation-Derived Waste/Sample Shipment

Details pertaining to sampling equipment, decontamination, and IDW should be clearly delineated in the work plan. However, the following information should be included in the logbook:

- The type of IDW generated and the number of containers generated (each drum should be numbered and its contents noted);
- All information relevant to the characterization of the IDW;

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- Any directions received from the client/workplan/contract relative to the management of the IDW;
- The disposition of IDW (left on site or removed from site);
- The number of sample containers shipped to the ASC or laboratory and the courier used (i.e., Federal Express, Airborne Express, etc.);
- Airbill or shipment tracking numbers; and
- The type of paperwork that accompanied the waste/sample shipment (e.g., manifests, etc.).

4.5 Photodocumentation

Photographs should be taken during all relevant field activities to confirm the presence or absence of contaminants encountered during fieldwork. Specific items to be documented include:

- Sample locations and collection activities;
- Site areas that have been disturbed or impacted, and any evidence of such impacts (i.e., stressed vegetation, seepage, discolored water, or debris);
- Hazardous materials requiring disposal, including materials that may not appear in the work plan;
- Any evidence that attests to the presence or absence of contamination; and
- Any features that do not appear in the work plan or differ from those described in the work plan.

Documentation of any photographs taken during the course of the project must be provided in the logbook with a detailed description of what is shown in the photograph and the reason for taking it. This documentation should include:

- Make, model, and serial numbers of the camera and lens,
- Film type and number of exposures,
- Roll and frame number of the photograph,



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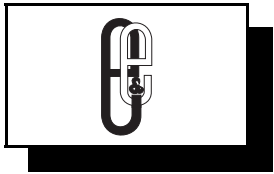
- Direction or view angle of the photograph, and
- Name of the photographer.

4.6 Data Collection Forms

Certain phases of fieldwork may require the use of project-specific data collection forms, such as task data sheets or hazard categorization data sheets. Due to the specific nature of these forms, the information that should be included in the logbook cannot be fully discussed in this SOP. However, the following data should be included in the logbook:

- Results of any field tests or hazard categorization tests (i.e., ignitability, corrosivity, reactivity, etc.);
- The source from which any field sample was collected and its condition (i.e., drum, tank, lagoon, etc.).
- Other conclusions as a result of the data collected on data collection forms.

In many cases, rubber stamps that contain routine data collection forms can be manufactured ahead of time. These forms can be stamped into the logbook on an as-needed basis.



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Appendix A

Sample Logbook

RI 6130

WEDNESDAY JANUARY 26, 1994

PROPOSED WORK FOR DAY: COLLECT GROUNDWATER

SAMPLES FROM WELLS AND PIEZOMETERS AT
SITE 1 AND SITE 3. SHIP SAMPLES TO THE
ASC. CONTAINERIZE PURGE WATER. MEET
WITH FRED CANSLER AND DISCUSS REMOVAL OF
CANOPIES AT SITES 1 AND 3 AND FILLING OF
EXCAVATIONS.

WEATHER ON SITE: CLOUDY AND WARM WITH
A HIGH TEMPERATURE OF 50° F. RAIN SHOWERS
WITH WINDS FROM THE SW AT 5-15 MPH.

EIE PERSONNEL ON SITE: G. JONES, J. MAYS,
S. MC CONE

LOG

1330 ARRIVED ON SITE. THE GROUNDWATER
SAMPLING CREW WAS PREPARING TO PURGE
THE WELLS AND PIEZOMETERS IN THE FIELD
ACROSS THE ROAD FROM SITE 1. PURGING OF
WELLS BEING COMPLETED WITH HAND BAILERS
SINCE PUMP IS IMPROPER.

1340 ARRIVED AT SITE 3. MW3-1 AND MW3-3
VALVED AND OPEN. SECURED BOTH WELLS.
38 *Sumline 1/26/94*

RI 6130

1/26/94

1330 FRED CANSLER ARRIVED ON SITE. DISCUSSED

REMOVAL OF CANOPIES AND CLOSURE OF EXCAVATIONS

AT SITES 1 AND 3. FRED CANSLER STATED THAT

HE HAS A SOURCE FOR THE ROCK AND FOR
THE TOP SOIL FOR THE EXCAVATIONS.

1405 ARRIVED AT THE SITE WHERE FRED CANSLER

PROPOSES TO REMOVE THE FILL FOR THE EXCAVATIONS.

A HILL ON THE WEST SIDE ⁴ OF THE WOODEN
NICKLE IS IN THE PROCESS OF BEING REMOVED.

THE ROCK CONSISTS OF WEATHERED SHALE SIMILAR
TO THE ROCK REMOVED FROM THE EXCAVATIONS.

FRED CANSLER PROPOSES TO USE THE ROCK TO
FILL THE EXCAVATIONS TO WITHIN ONE FOOT
OF GRADE.

1415 ARRIVED AT THE SITE WHERE FRED CANSLER

PROPOSES TO REMOVE TOP SOIL FOR THE EXCAVATIONS.

TOP SOIL REMOVED FROM THE YELLOW FREIGHT

LOT IS IN PILES ON THE NORTH SIDE OF THE
LOT.

1430 RETURNED TO SITE 3. FRED CANSLER WILL

ARRANGE TO REMOVE THE CANOPY OVER

THE EXCAVATION AT SITE 3 ON THURSDAY

MORNING AND WILL ARRANGE TO BRING

THE ROCK IN ON THURSDAY AFTERNOON.

TWO TRUCKS WILL BE USED TO HAUL THE

FILL. THE SUPPORTS HOLDING THE CANOPY

39 *Sumline 1/26/94*

1/26/94 RI 6130
 1430 (cont) WILL BE CUT AND THE CANOPY DRAGGED AWAY FROM THE EXCAVATION.
 1445 CONTACTED JOY INMAN FROM ENVIRONICS. TANKERS WILL BE ON SITE ON THURSDAY TO PUMP OUT THE EXCAVATION AT SITE 3 AND ON FRIDAY TO REMOVE WATER AT SITE 1. A FRAC TANK WILL BE DELIVERED TO SITE 1 ON THURSDAY.
 1515 SAMPLING CREW COMPLETED PACKING SAMPLES COLLECTED AT SITE 1. ALL WELLS AND PIEZOMETERS AT SITE 1 HAVE BEEN SAMPLED.
 1530 SAMPLING CREW COMPLETED PACKING SAMPLES AND SECURING DRUMS OF PURGE WATER.
 1535 SAMPLING CREW DEPARTED SITE TO DELIVER SAMPLES TO FEDERAL EXPRESS.
 1600 CONTACTED TIM GRADY FROM E+E. DISCUSSED CONVERSATION WITH FRED CANSLER AND STATUS OF WELL/PIEZOMETER SAMPLING.
 1615 SECURED FOR DAY.
 WORK COMPLETED: COLLECTED GROUNDWATER SAMPLES FROM SITE 1 WELLS AND PIEZOMETERS. DISCUSSED REMOVAL OF CANOPIES AND FILLING OF EXCAVATIONS WITH FRED CANSLER. SHIPPED SAMPLES TO ASC.

John R. Jones
 1/26/94
 40

THURSDAY JANUARY 27, 1994 RI 6130
 PROPOSED WORK FOR DAY: COMPLETE COLLECTION OF GROUNDWATER SAMPLES AT SITE 3 AND SHIP THE SAMPLES TO THE ASC. REMOVE THE CANOPIES COVERING THE EXCAVATIONS AT SITES 1 AND 3. PUMP THE WATER OUT OF THE EXCAVATIONS AT SITES 1 AND 3 AND SHIP THE WATER OFF SITE TO OSCO. BACKFILL THE EXCAVATION AT SITE 3. REMOVE THE DRUMS FROM THE ROLL OFF BOX AND TRANSFER THE DRUMS TO THE WAREHOUSE.
 WEATHER ON SITE: CLOUDY AND COOL WITH A HIGH TEMPERATURE OF 45°F. WINDS VARIABLE 10-20 MPH.
 E+E PERSONNEL ON SITE: G. JONES, J. MAYS, S. MCCONE
 LOG
 0700 SCOTT MCCONE ARRIVED AT SITE 3.
 0710 ENVIRONICS PERSONNEL ARRIVED AT SITE 3.
 0715 HELD SITE SAFETY MEETING. DISCUSSED PHYSICAL AND CHEMICAL HAZARDS ASSOCIATED WITH SITE AND PROPOSED WORK FOR THE DAY.
 0725 E+E SAMPLING TEAM ARRIVED ON SITE.
 41 *John R. Jones* 1/27/94

1/27/94 RI 6130
 0730 E+E SAMPLING CREW COMMENCED COLLECTING
 SAMPLES AND PURGING MW 3-1 AND MW 3-2.
 0800 FRED CANSLER ARRIVED ON SITE WITH
 PERSONNEL TO REMOVE THE CANOPY OVER
 THE EXCAVATION AT SITE 3. THE SUPPORTS
 WERE CUT AND THE CANOPY WAS DRAGGED
 AWAY FROM THE EXCAVATION WITH TWO
 TRACTORS.
 0845 THE CANOPY REMOVAL AT SITE 3 COMPLETED
 AND THE CREW DEPARTED FOR SITE 1.
 0850 COMMENCED PUMPING WATER FROM THE
 EXCAVATION INTO BRYSON TRAILER # 618CS.
 0915 THE E+E SAMPLING TEAM COMPLETED COLLECTING
 THE GROUNDWATER SAMPLES FROM MW 3-1,
 MW 3-2, MW 3-3, AND MW 3-4. COMMENCED
 PACKING SAMPLES.
 0935 COMPLETED FILLING BRYSON TRAILER # 618CS
 WITH 5,000 GALLONS OF WATER AND PREPARED
 MANIFEST # 00941 FOR LOAD. COMMENCED
 LOADING BRYSON TRAILER # 429.
 1000 E+E SAMPLING TEAM DEPARTED THE SITE
 TO DELIVER SAMPLES TO FEDERAL EXPRESS.
 1030 ARRIVED AT SITE 1. THE CANSLER CREW
 IS IN THE PROCESS OF REMOVING THE
 CANOPY OVER THE EXCAVATION. CANOPY
 IS NOT MOVING AS A UNIT.
 42 *John C. 1/27/94*

RI 6130 1/27/94
 1045 RETURNED TO SITE 3. ALL WATER IN THE
 EXCAVATION HAS BEEN REMOVED EXCEPT
 FOR THE ICE. BRYSON TRAILER # 429
 LOADED WITH 5,200 GALLONS OF WATER. PREPARED
 MANIFEST # 00942 FOR LOAD. BOTH TRAILERS
 DEPARTED THE SITE.
 1100 ENVIRONICS PERSONNEL OPENED THE DRUMS
 OF DRILLING FLUIDS, DEVELOPMENT WATER
 AND PURGE WATER AND FOUND THE DRUMS
 FULL OF ICE. ENVIRONICS WILL CONTACT
 GARY SHOCKLEY AND RECOMMEND THAT
 THE DRUMS OR LIQUIDS BE TRANSPORTED
 TO OSED FOR TREATMENT SINCE THEY
 CAN NOT BE BULKED.
 1200 CANSLER CREW COMMENCED LOADING TRUCKS
 WITH STONE FROM THE SITE WEST OF
 THE WOODEN NICKEL.
 1230 ARRIVED AT THE SITE WHERE THE STONE
 WAS BEING LOADED. THE FILL MATERIAL
 IS ALL UNDISTURBED WEATHERED BEDROCK.
 1245 ARRIVED AT SITE 3. TWO LOADS OF
 ROCK FILL HAVE BEEN DUMPED IN THE
 EXCAVATION; AN ESTIMATED FOUR MORE
 LOADS OF STONE WILL BE NEEDED TO
 FILL THE EXCAVATION.
 1300 ARRIVED AT SITE 1. BRYSON TRAILER # 617
 43 *John C. 1/27/94*



TITLE: GEOLOGIC LOGGING

CATEGORY: GEO 4.8

REVISED: March 1998

STANDARD OPERATING PROCEDURE

GEOLOGIC LOGGING

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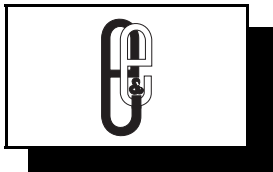
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TITLE:	GEOLOGIC LOGGING		
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1. Introduction

Geologic logging involves keeping detailed records during the drilling of boreholes, the installation of monitoring wells, and the excavation of test pits, and entering the geologic descriptions of the soil and rock samples recovered on a standardized form. E & E has adapted a standardized geotechnical logbook (see DOC 2.4 in E & E's Standard Operating Procedures [SOPs]) that contains items deemed important to record when installing monitoring wells, piezometers, and/or soil borings. This document discusses general procedures for completing geologic logs.

2. Drilling Logs

2.1 Basic Documentation

When drilling boreholes, the project geologist should maintain a log that describes each borehole. The E & E Geotechnical Logbook contains records for boreholes. The following basic information should be entered on the heading of each drilling log sheet (see Figure 1):

- Borehole/well number;
- Project name;
- Site location;
- Dates and times that drilling was started and completed;
- Drilling company;
- E & E geologist's name;
- Drill rig type used to drill the borehole;
- Drilling method(s) used to drill the borehole;

**TITLE:****GEOLOGIC LOGGING****CATEGORY:****GEO 4.8****REVISED:****March 1998****DRILLING LOG FOR** _____

Project Name _____

Site Location _____

Date Started/Finished _____

Drilling Company _____

Driller's Name _____

Geologist's Name _____

Geologist's Signature _____

Rig Type(s) _____

Drilling Method(s) _____

Bit Size(s) _____ Auger Size(s) _____

Auger/Split Spoon Refusal _____

Total Depth of Borehole is _____

Total Depth of Corehole is _____

Water Level (TOIC)

Date	Time	Level (Feet)

Well Location Sketch

Depth (Feet)	Sample Number	Blows on Sampler	Soil Components CL SI S GR	Rock Pile	Penetration Times	Run Number	Core Recovery	RQD	Fracture Sketch	HNu/OVA (ppm)	Comments
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											

Figure 1 Drilling Log



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- Bit and auger size(s);
- Depth of auger/split barrel sampler refusal;
- Total depth of borehole;
- Total depth of corehole (if applicable);
- Water level at time of completion measured from top of inside casing (TOIC); and
- A well location sketch.

2.2 Technical Information

During the drilling of a borehole, specific technical information about the unconsolidated material and rock encountered should be recorded on the drilling log sheet. The following minimum technical information should be recorded:

- Depth that sample was collected or encountered;
- Sample number assigned (if applicable);
- The number of blow counts required to drive the split barrel sampler 2 feet at 6-inch intervals (see Table 1);
- Description of soil components (see Figure 2);
- Description of rock profile (see Figure 3);
- Rock qualitative designation (RQD) (see Figure 4);
- Rock penetration time;
- Core run number (if applicable) and percent recovery; and
- Organic vapor readings in the sample.

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Table 1	
STANDARD PENETRATION TEST FOR SOIL DENSITY	
N-Blows/Feet	Relative Density
Cohesionless Soils	
0 - 4	Very loose
4 - 10	Loose
10 - 30	Medium
30 - 50	Dense
50	Very dense
Cohesive Soils	
2	Very soft
2 - 4	Soft
4 - 8	Medium
8 - 15	Stiff
15 - 30	Very stiff
30	Hard

3. Soil Classification

Soils should be described using the Unified Soil Classification System (USCS) in the narrative lithologic description section of Figure 5. Figure 6 is a summary of the American Society for Testing and Materials (ASTM) criteria for describing soils. Soil descriptions should be concise, stressing major constituents and characteristics, and should be given in a consistent order and format. The following order is recommended by the ASTM:

1. Soil name. The basic name of the predominant constituent and a single-word modifier indicating the major subordinate constituent.

**TITLE:****GEOLOGIC LOGGING****CATEGORY:****GEO 4.8****REVISED:****March 1998****SOIL AND SEDIMENT CLASSIFICATION**

GRAIN-SIZE SCALE (Modified Wentworth Scale)				
U.S. Standard				
phi	mm	inches	Sieve Series	Grade Name
-12	4096	161.30		very large
-11	2048	80.60		large
-10	1024	40.30		medium
-9	512	20.20		small
-8	256	10.10		large
-7	128	5.00		small
-6	64	2.52	63.0 mm	very coarse
-5	32	1.28	31.5 mm	coarse
-4	16	0.63	16.0 mm	medium
-3	8	0.32	8.0 mm	fine
-2	4	0.16	No. 5	very fine
-1	2	0.08	No. 10	very coarse
0	1	0.04	No. 18	coarse
+1	0.500		No. 35	medium
+2	0.250		No. 60	fine
+3	0.125		No. 120	very fine
+4	0.062		No. 230	coarse
+5	0.031			medium
+6	0.016			fine
+7	0.008			very fine
+8	0.004			coarse
+9	0.002			medium
+10	0.001			fine
+11	0.0005			very fine
+12	0.00025			

PROPORTIONS USED IN DESCRIBING SOILS

Trace - Particles are present but estimated to be less than 5%
Few - 5 to 10%
Little - 15 to 25%
Some - 30 to 45%
Mostly - 50 to 100%

i.e.: Sand with a trace of silt
= 95% Sand, < 5% Silt

(When sampling gravelly soils with a standard split spoon, the true percentage of gravel is often not recovered due to relatively small sample diameter.)

Soil Density from Standard Penetration Test (ASTM D1586)

Granular Soils	Cohesive Soils
0 - 10: Loose	0 - 4: Soft
10 - 30: Medium Dense	4 - 8: Medium Stiff
30 - 50: Dense	8 - 15: Stiff
Over 50: Very Dense	15 - 30: Very Stiff

CLASSIFICATION CHART (United Soil Classification System)

MAJOR DIVISIONS		Symbols	TYPICAL NAMES	
Coarse Grained Soils (More than 1/2 of soil > no 200 sieve size)	GRAVELS (More than 1/2 of coarse fraction > No. 4 sieve size)	GW	Well-graded gravels or gravel-sand mixtures, little or no fines	
		GP	Poorly graded gravels or gravel-sand mixtures little or no fines	
		GM	Silty gravels, gravel-sand-silt mixture	
		CC	Clayey gravels, gravel-sand-clay mixtures	
	SANDS (More than 1/2 of coarse fraction < No. 4 sieve size)	SW	Well-graded sands or gravelly sands, little or no fines	
		SP	Poorly graded sands or gravelly sands, little or no fines	
		SM	Silty sands, sand-silt mixtures	
		SC	Clayey sands, sand clay mixtures	
Fine Grained Soils (More than 1/2 of soil < no 200 sieve size)	SILTS AND CLAYS LL < 50	ML	Inorganic silts, and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	
		CL	Inorganic clays, of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
		OL	Organic silts and organic clays of low plasticity	
	SILTS AND CLAYS LL > 50	MH	Inorganic silts, micaceous or diatomaceous, fine sandy or silty soils, elastic silts	
		CH	Inorganic clays of high plasticity, fat clays	
		OH	Organic clays of medium to high plasticity, organic silty clays, organic silts	
	HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils

Figure 2 USCS Soil Classification Chart



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CATEGORY: GEO 4.8

REVISED: March 1998

ROCK DESCRIPTIVE TERMS

Term		Defining Characteristics
Hardness	Soft	Scratched by fingernail
	Moderately Hard	Scratched easily by penknife
Hard	Hard	Difficult to scratch with a penknife
	Very Hard	Cannot be scratched by penknife
Weathering	Unweathered	Rock is unstained. May be fractured, but discontinuities are not stained.
	Slighty	Rock is unstained. Discontinuities show some staining on the surfaces of rocks, but discoloration does not penetrate rock mass.
	Moderate	Discontinuity surfaces are stained. Discoloration may extend into rock along discontinuity surfaces.
	High	Individual rock fragments are thoroughly stained and may be crumbly.
	Severe	Rock appears to consist of gravel-sized fragments in a "soil" matrix. Individual fragments are thoroughly discolored and can be broken with fingers.
Bedding Planes	Laminated	< .04 in. < 1 mm
	Parting	.04 in. - .24 in. 1mm - 6mm
	Banded	.24 in. - 1in. 6 mm - 3 cm
	Thin	1 in. - 4 in. 3 cm - 9.1 cm
	Medium	4 in. - 12 in. 9.1 cm - 30.5 cm
	Thick	12 in. - 36 in. 30.5 cm - 1m
	Massive	> 36 in. > 1 m
Joints and Fracture Spacing	Very tight	< 2 in. < 5.1 cm
	Tight	2 in. - 1ft. 5.1 - 30.5 cm
	Moderately tight	1ft. - 3 ft. 30.5 cm - 91.4 cm
	Wide	3 ft. - 10 ft. 91.4 cm - 3 M
	Very wide	> 10 ft. > 3 M
Voids	Porous	Smaller than a pinhead. Their presence is indicated by the degree of absorbency.
	Pitted	Pinhead size to a 1/4 inch. If only thin walls separate the individual pits, the core may be described as honeycombed.
	Vug	1/4 inch to the diameter of the core. The upper limit will vary with core size.
	Cavity	Larger than the diameter of the core.

Rock Particle Percent Composition Estimation



1%



5%



10%



15%



25%



50%

Figure 3 Rock Descriptive Terms

**TITLE:****GEOLOGIC LOGGING****CATEGORY:****GEO 4.8****REVISED:****March 1998**

ROCK QUALITY DESIGNATION (RQD) AND FRACTURE FREQUENCY

Core borings are a useful means of obtaining information about the quality of rock mass. The recoverable core indicates the character of the intact rock and the number and character of the natural discontinuities.

Another quantitative index that has proved useful in logging NX core is a rock quality designation (RQD) developed by Deere (1963). The RQD is a modified core recovery percentage in which all the pieces of sound NX core over 4 inches long are counted as recovery. The length of the core run is the distance to the nearest tenth of a foot from the corrected depth of the hole at the end of the previous run to the corrected depth of the hole at the end of subject run. The smaller pieces are considered to be due to close shearing, jointing, faulting, or weathering in the rock mass and are not counted. The RQD is a more general measure of the core quality than the fracture frequency. Core loss, weathered and soft zones, as well as fractures, are accounted for in this determination. The RQD provides a preliminary estimate of the variation of the *in situ* rock mass properties from the properties of the "sound" portion of the rock core. Thus, a general estimate of the behavior of the rock mass can be made. An RQD approaching 100 percent denotes an excellent quality rock mass with properties similar to that of an intact specimen. RQD values ranging from 0 to 50 percent are indicative of a poor quality rock mass having a small fraction of the strength and stiffness measured for an intact specimen.

RQD (Rock Quality Designation)

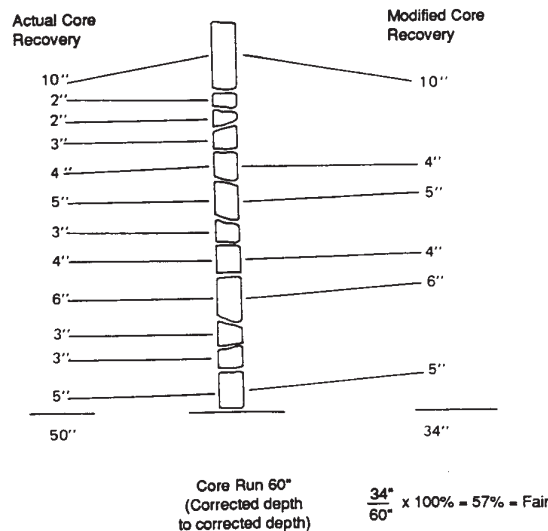
0 - 25 Very Poor
25 - 50 Poor
50 - 75 Fair
75 - 90 Good
90 - 100 Excellent

An example of determining the RQD from a core run of 60 inches measured from corrected depth to corrected depth is given in Diagram 1. For this particular case, the core recovery was 50 inches and the modified core recovery was 34 inches. This yields an RQD of 57 percent, classifying the rock mass in the fair category.

Problems arise in the use of RQD for determining the *in situ* rock mass quality. The RQD evaluates fractures in the core caused by the drilling process, as well as in natural fractures previously existing in the rock mass. For example, when the core hole penetrates a fault zone or a joint, additional breaks may form that, although not natural fractures, are caused by natural planes of weakness existing in the rock mass. These fresh breaks occur during drilling and handling of the core and are not related to the quality of the rock mass. The skill of the driller will affect the amount of breakage and the core loss that occurs. Poor drilling techniques will "penalize" the rock by lowering its apparent quality. It is difficult to distinguish between drilling breaks and those natural and incipient fractures that reflect the quality of the rock mass. In certain instances, it may be advisable to include all fractures when estimating RQD. Obviously, some judgement is involved in core logging.

Another problem with the use of the RQD index is that the determinations are not sensitive to the tightness of the individual joints, whereas in some instances, the *in situ* deformation modulus may be strongly affected by the average joint opening.

RQD OF A SINGLE CORE RUN *



* Typical calculation of RQD of a single core run. Note that the run is calculated from corrected depth to corrected depth.

Figure 4 Rock Qualitative Designation (RQD)



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SCREENED WELL		OPEN-HOLE WELL	
Stick-up _____ ft	Lock Number _____	Stick-up _____ ft	
Inner Casing Material _____		Inner Casing Material _____	
Inner Casing Inside Diameter _____ inches		Inner Casing Inside Diameter _____ inches	
Top of Grout _____ ft	Quantity of Material Used:	Top of Grout _____ ft	
Borehole _____ inches	Bentonite Pellets _____	Bottom of Outer Casing _____ ft	
Diameter _____ ft	Cement _____	Borehole Diameter _____ ft	
Top of Seal at _____ ft	Cement/Bentonite _____	Bedrock _____ ft	
Bottom of Seal at _____	Grout _____	Bottom of Rock Socket/ Grout/ Casing _____ ft	
Top of Screen at _____ ft	Top of Sand Pack _____	Corehole Diameter _____	
Pack Type/Size:	Screen Slot Size _____	Bottom of Corehole _____ ft	
<input type="checkbox"/> Sand _____	Screen Type _____		
<input type="checkbox"/> Gravel _____	<input type="checkbox"/> PVC _____		
<input type="checkbox"/> Natural _____	<input type="checkbox"/> Stainless Steel _____		
Bottom of Screen at _____ ft	Bottom of Hole at _____ ft		
	Bottom of Sandpack at _____		

NOTE: See pages 109 and 110 for well construction diagrams

Depth-ft.	NARRATIVE LITHOLOGIC DESCRIPTION	Moisture Content		
		Dry	Moist	Wet
1		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
11		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
12		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
13		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
14		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Figure 5 Narrative Lithologic Description



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ASTM CRITERIA FOR DESCRIBING SOIL			
Criteria for Describing Angularity of Coarse-Grained Particles		Criteria for Describing Dry Strength	
Description	Criteria	Description	Criteria
Angular	Particles have sharp edges and relatively plane side with unpolished surfaces	None	The dry specimen crumbles into powder with mere pressure of handling
Subangular	Particles are similar to angular description but have rounded edges	Low	The dry specimen crumbles into powder with some finger pressure
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges	Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
Rounded	Particles have smoothly curved side and no edges	High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface.
		Very High	The dry specimen cannot be broken between the thumb and shard surface
Criteria for Describing Dilatancy		Criteria for Describing Structure	
Description	Criteria	Description	Criteria
None	No visible change in the specimen.	Stratified	Alternating layers of varing material or color with layers at least 6 mm thick; note thickness.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.	Laminated	Alternating layers of varying materials or color with the layers less than 6 mm thick; note thickness.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.	Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Criteria for Describing Toughness		Slickensided	Fracture planes appear polished or glossy, sometimes striated.
Description	Criteria	Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown.
Low	Only slight pressure is required to roll the thread near the plastic limit . The thread and the lump are weak and soft.	Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness.
Medium	Medium pressure is required to roll the thread to near plastic limit. The thread and the lump have medium stiffness.	Homo-geneous	Same color and appearance throughout.
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness.		

Figure 6 ASTM Criteria for Describing Soil



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CRITERIA FOR DESCRIBING SOIL (Cont.)

Criteria for Describing the Reaction with HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

Criteria for Describing Consistency

Description	Criteria
Very Soft	Thumb will penetrate soil more than 1 inch (25 mm)
Soft	Thumb will penetrate soil about 1 inch (25 mm)
Firm	Thumb will indent soil about 1/4 inch (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very Hard	Thumbnail will not indent soil

Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

Criteria for Describing Particle Shape

The particle shape shall be described as follows where length, width, and thickness refer to greatest, intermediate, and least dimensions of a particle, respectively (see page 104).

Flat	Particles with width/thickness ratio > 3
Elongated	Particles with length/width ratio > 3
Flat and Elongated	Particles meet criteria for both flat and elongated

Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A 1/8 inch (3 mm) thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

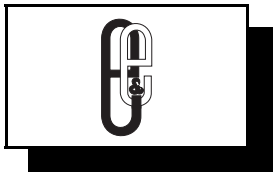
Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

Figure 6 ASTM Criteria for Describing Soil (cont.)



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2. Gradation or Plasticity. Granular soils (i.e., sands or gravels) should be described as well-graded, poorly-graded, uniform, or gap-graded, depending on the gradation of the minus 3-inch fraction. Cohesive soils (i.e., silts and clays) should be described as nonplastic, slightly plastic, moderately plastic, or highly plastic, depending on results of the manual evaluation for plasticity.
3. Particle size distribution. An estimate of the percentage and grain-size range of each subordinate constituent of the soil. This description may also include a description of angularity (see Figure 7).
4. Color. The basic color of the soil.
5. Moisture content. The amount of soil moisture (dry, moist, or wet).
6. Relative density or consistency. An estimate of density of a granular soil or consistency of a cohesive soil, usually based on the standard penetration test results (see Table 1).
7. Soil Structure or Mineralogy. Description of discontinuities, inclusions, and structures. Includes joints, fissures, and slickensides.

4. Core Logging

4.1 Handling of Core

After the core has been recovered from the corehole and the core barrel has been opened, the core should be placed in a core box. The top of the core should be placed at the back left corner of the core box, and the remaining core placed to the right of the preceding section (see Figure 8). The core box should be filled in this manner, moving to the front sections of the core box. The beginning of each run should be marked on the core and also noted with a marked wooden block.

4.2 Rock Description

Each stratigraphic unit in the core shall be logged. A line marking the depth of the top and the bottom of the unit shall be drawn horizontally. In classifying the rock, the geologist should avoid being too technical, as the information presented must be used by numerous people with widely divergent backgrounds.



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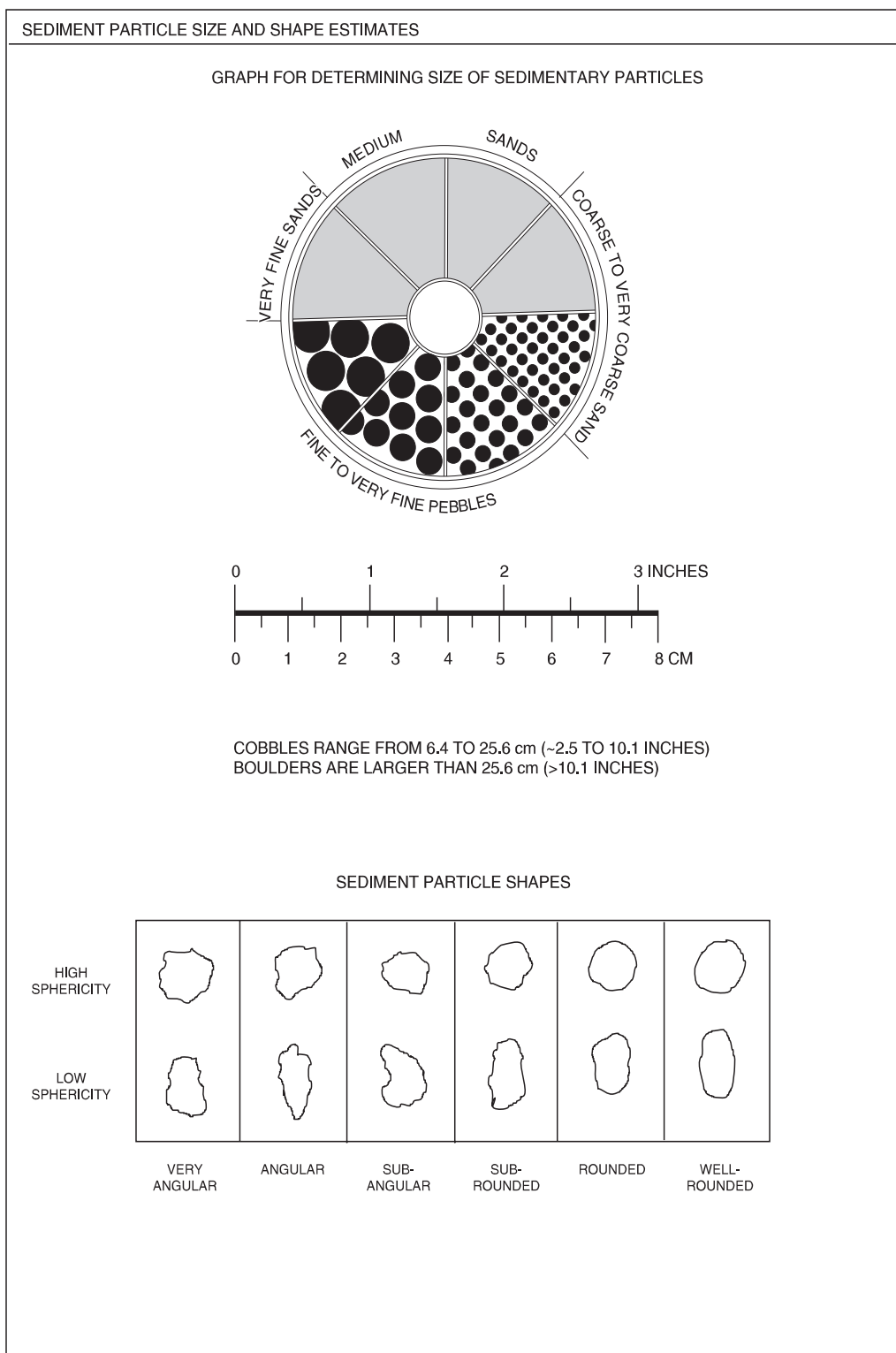


Figure 7 Sediment Particle Size and Shape Estimates



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ABC LANDFILL SYRACUSE, NEW YORK XA-6022	MONITORING WELL MW-1 BOX 1 OF 2 CORE RUN 1 12.5' - 22.5' BEGINNING CORE RUN 2 22.5' - 30.5'
---	--

EXAMPLE: OUTSIDE CORE BOX COVER

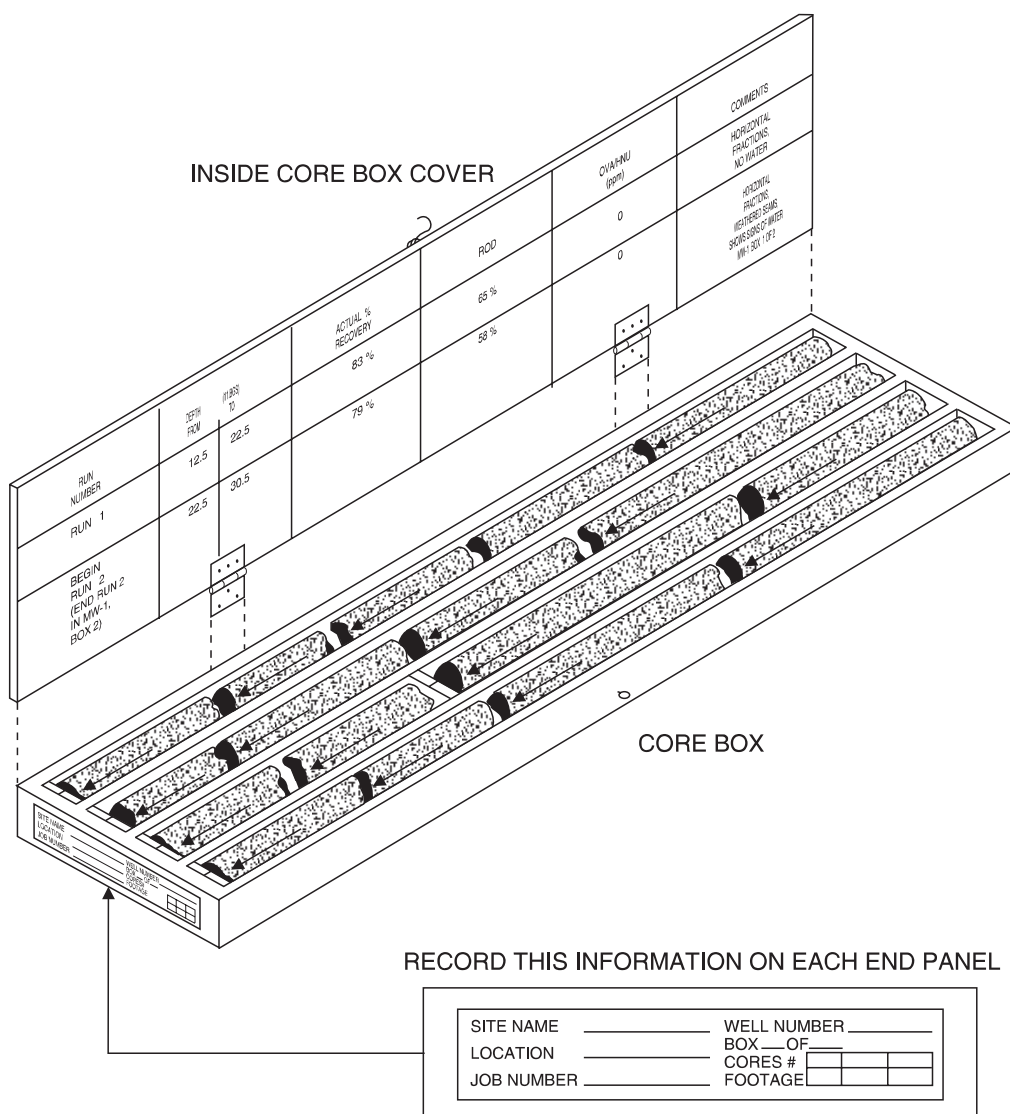


Figure 8 Core Box



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The classification and description of each unit should be given in the following order, as applicable:

1. Unit designation (Miami oolite, Clayton Formation, Chattanooga shale);
2. Rock type;
3. Hardness;
4. Degree of weathering;
5. Texture;
6. Structure;
7. Color;
8. Solution and void conditions;
9. Swelling properties;
10. Slaking properties; and
11. Additional description, such as mineralization, size, and spacing shale seams, etc.

Variations from the general description of the unit and features not included in the general description shall be indicated by brackets and lines to show the depth and the interval in the core where the feature exists. These variations and features shall be identified by terms that will adequately describe the feature or variation so as to delineate it from the unit. These may be zones or seams of different color, texture, etc., from that of the unit as a whole, such as staining; variations in texture; shale seams, gypsum seams, chert nodules, calcite masses, etc.; mineralized zones; vuggy zones, joints, fractures; open and/or stained bedding planes; faults, shear zones, gouge; cavities' thickness, open or filled, nature of filling, etc.; or any core left in the bottom of the hole after the final pull.

Rock Type and Lithology

1. Rock will be classified according to the following 24 types:
 - Sandstone



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- Conglomerate
- Coal
- Compaction Shale
- Cemented Shale
- Indurated Clay
- Limestone
- Chalk
- Gneiss
- Schist
- Graywacke
- Quartzite
- Dolomite
- Marble
- Soapstone and Serpentine
- Slate
- Granite
- Diorite
- Gabbro
- Rhyolite
- Andesite
- Basalt



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- Tuff or Tuff Breccia
 - Agglomerate or Flow Breccia
2. Lithologic characteristics should be included to differentiate rocks of the same classification. These adjectives should be simple and easily understood, such as shaly, sandy, dolomitic, etc. Inclusions, nodules, and concretions should also be noted here.
 3. It is important to maintain a simple but accurate rock classification. The rock type and lithologic characteristics are essentially used to differentiate the rock units encountered.

Hardness

The terms for hardness, as outlined below, were modified to include the use of a rock hammer.

1. **Very soft** or plastic - can be deformed by hand (has a rock-like character but can be broken easily by hand).
2. **Soft** - can be scratched with a fingernail (cannot be crumbled between fingers but can be easily pitted with light blows of a geology hammer).
3. **Moderately hard** - can be scratched easily with a knife; cannot be scratched with a fingernail (can be pitted with moderate blows of a geology hammer).
4. **Hard** - difficult to scratch with a knife (cannot be pitted with a geology hammer but can be chipped with moderate blows of the hammer).
5. **Very hard** - cannot be scratched with a knife (chips can be broken off only with heavy blows of the geology hammer).

Weathering

The degree and depth of weathering is very important and should be accurately detailed in the general description and clearly indicated on the drill log.

1. **Unweathered** - no evidence of any mechanical or chemical alteration.



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2. **Slightly weathered** - superficial discoloration, alteration, and/or discoloration along discontinuities; less than 10% of the rock volume is altered; strength is essentially unaffected.
3. **Moderately weathered** - discoloration is evident; surface is pitted and altered, with alterations penetrating well below rock surfaces; 10% to 50% of the rock is altered; strength is noticeably less than unweathered rock.
4. **Highly weathered** - entire section is discolored; alteration is greater than 50%; some areas of slightly weathered rock are present; some minerals are leached away; retains only a fraction of its original strength (wet strength is usually lower than dry strength).
5. **Decomposed** - saprolite; rock is essentially reduced to a soil with a relic rock texture; can be molded or crumbled by hand.

Texture

Texture is used to denote the size of the grains or crystals comprising the rock, as opposed to the arrangement of the grains or crystals, which is considered a structure.

1. **Aphanitic** - grain diameter less than 0.004 inch (0.1 mm); individual grains or crystals are too small to be seen with the naked eye.
2. **Fine-grained, finely crystalline** - grain diameter between 0.004 inch (0.1 mm) and 0.003 (1 mm); grains or crystals can be seen with the naked eye.
3. **Medium-grained, crystalline** - grain diameters between 0.003 foot (1 mm) and 0.0175 foot (5 mm).
4. **Coarse-grained, coarsely crystalline** - grain diameter greater than 0.0175 foot (5 mm).

Structure

The structural character of the rock shall be described in terms of grain or crystal alignment, bedding, and discontinuities, as applicable. The terms may be used singularly or paired.



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1. **Foliation and/or lineation** - give approximate dip uniformity, degree of distinctiveness, banding, etc.
2. **Joints:**
 - a. Type - bedding, cleavage, foliation, extension, etc.
 - b. Degree of openness - tight or open.
 - c. Surface or joint plane characteristics - smooth, rough, undulating.
 - d. Weathering - degree, staining.
 - e. Frequency - see (4).
3. **Fractures, shears, gouge:**
 - a. Nature - single plane or zone. (Note thickness.)
 - b. Character of materials in plane or zone.
 - c. Slickensides.
4. **Frequency:**
 - a. Intact - spacing greater than 6 feet (2 m).
 - b. Slightly jointed (fractured) - spacing 3 feet (1 m) to 6 feet (2 m).
 - c. Moderately jointed (fractured) - spacing 1 foot (0.3 m) to 3 feet (1 m).
 - d. Highly jointed (fractured) - spacing 0.3 foot (9.1 cm) to 1 foot (0.3 m).
 - e. Intensely jointed (fractured) - spacing less than 0.3 foot (9.1 cm).
5. **Bedding** is used to describe the average thickness of the individual beds within recognized unit, and the terms thick, medium, or thin should not be applied to the individual beds. "Parting" and "band" are used to describe single stratum as outlined below:
 - a. Massive - over 3 feet thick (1 m).
 - b. Thick - 1 foot (30.5 cm) to 3 feet (1 m) thick.
 - c. Medium - 0.3 foot (9.1 cm) to 1 foot (30.5 cm) thick.
 - d. Thin - 0.1 foot (3.0 cm) to 0.3 foot (9.1 cm) thick.
 - e. Band - 0.02 foot (6 mm) to 0.1 foot (3.0 cm) thick, described to the nearest 0.01 foot.
 - f. Parting - less than 0.02 foot (6 mm).
 - g. Paper-thin parting.

The terms and descriptions for the structure of the rock are to be used to describe the character of the rock units recognized and are not to be used as a substitute for describing individual discontinuities. Except for areas where the rock is intensely fractured or jointed, each discontinuity should be described on the log as to position, dip, staining, weathering, breccia, gouge, etc.

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Color is often valuable in correlating or differentiating samples, but can be misleading or uninformative. The color of a sample should represent the sample in terms of basic hues (i.e., red, blue, gray, black), supplemented with modifying hues as required (i.e., bluish gray, mottled brown). The core should be surface wet when describing the color; if it is dry, the log should indicate "dry color." Subjective colors, such as buff or maroon, should not be used. Specific color charts, such as the Munsel Color Chart or the Color Index in the Colorado School of Mines, Quarterly, Volume 50, No. 1, are useful in describing color of samples. When such a chart or index is used, it should be noted on the log in the remarks column.

Solution and Void Conditions shall be described in detail, as these features can affect the strength of the rock and can indicate potential seepage paths through the rock. When cavities are detected by drill action, the depth to top and bottom of the cavity should be determined by measuring the stick-up of the drill tools when the cavity is first encountered and again at the bottom, as it is very difficult to reconstruct cavities from the core alone. Filling material, when present and recovered, should be described in detail opposite the cavity. When no material is recovered from the area of the cavity, the inspector should note the probable conditions of the cavity as determined from observing the drilling action and the color of the drill fluid. If the drill action indicated material was present (i.e., slow rod drop, no loss of drill water, noticeable change in color of water return), it should be noted on the log that the cavity was probably filled and the materials should be described as best as possible from the cuttings or traces left on the core. If drill action indicates the cavity was open (i.e., no resistance to the drill tools, loss of drill fluid), this should be noted on the drill log. Partially filled cavities should also be noted. All of these observations require close observation of the drill action and water return by both the inspector and the driller; accurate measurement of stick-ups; and detailed inspection of the core. When possible, filling material should be wrapped in foil if left in the core box. If the material is to be tested or examined in the lab, it should be sealed in a jar with proper labels and a spacer, with a note showing the disposition of the material should be placed in the core box at the point from which the material was taken. Terms to describe voids encountered shall be as follows:

1. **Porous** - voids less than 0.003 foot (1 mm) in diameter.
2. **Pitted** - voids 0.03 foot (1 mm) to 0.02 foot (6 mm) in diameter.
3. **Vug** - voids 0.02 foot (6 mm) to the diameter of the core.
4. **Cavity** - voids greater than diameter of the core.



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4.3 Core Labeling

The top of the core should be shown on each piece of core with an arrow written in a black, waterproof marker. The arrow will indicate which end of the core is nearer the ground surface. Other core markings may include locations of mechanical breaks and drilling footages.

4.4 Core Box Labeling

Each core box should be labeled as follows:

- On the top left corner of the outer core box, the project name, site location (city and state), and project number should be written.
- On the lower right corner of the outer core box, the corehole number (e.g., MW1, BH2), core box number (e.g., 1 of 2, 2 of 2), and the interval of the core run contained in the core box should be written.
- The side panels should be marked as indicated in Figure 8.
- The inside of the core box cover should be marked as indicated in Figure 8.

4.5 Core Storage

It is important to use proper-sized (HQ or NQ) wooden core boxes for rock core storage. After labeling the box and before closing the box for final storage or shipment, wooden spacers should be inserted into each compartment that contains rock core. This will prevent lateral movement of the cores, which could damage the rock material during handling.

After properly logging, labelling, and packing the cores, the core boxes should be stored in a dry location, preferably off of the floor on a pallet. The boxes can be stacked to a reasonable height so as not to be unstable, with end labelling facing out.

5. References

American Society for Testing and Materials (ASTM), 1975, Test Method for Classification of Soils for Engineering Purposes, ASTM D2487-69, Philadelphia, Pennsylvania.



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GROUNDWATER WELL SAMPLING

CATEGORY

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STANDARD OPERATING PROCEDURE

GROUNDWATER WELL SAMPLING

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1. Introduction

The objective of this Standard Operating Procedures (SOP) document is to provide recommended procedures for the sampling of groundwater wells, and is primarily concerned with the collection of water samples from the saturated zone of the subsurface. Every effort must be made to ensure that the sample is representative of the particular zone of water being sampled. Groundwater sampling procedures appropriate to the project objectives and site conditions will define a sampling event.

Analysis of groundwater samples may determine pollutant concentrations and its risk to public health, welfare, or the environment; extent of contaminants; and confirmation of remedial standards.

2. Scope

This document describes procedures for obtaining representative groundwater samples, quality assurance/quality control (QA/QC) measures to be followed, proper documentation of sampling activities, and recommendations for personnel safety.

3. Method Summary

Before sampling a monitoring well, the well must be purged. This may be done with a number of portable devices, including bailers, submersible pumps, bladder pumps, gas-driven pumps, gas-lift pumps, suction-lift pumps, and inertial-lift pumps. Refer to the E & E Standard Operating Procedure for *Groundwater Sampling Devices* (ENV 3.6) for information on different groundwater purging and sampling devices.

A minimum of three well volumes should be removed during well purging to ensure that a representative sample of the groundwater will be sampled. Once the purging is completed and the properly prepared sample containers have been selected, sampling may proceed. Numerous types of sampling devices may be selected for the collection of the groundwater sample, but care should be taken when selecting the sampling device, as some will affect the integrity of the sample.

Sampling should occur in a progression from the least to most contaminated well, if known. Ideally, a dedicated sampling device should be used for each well. However, dedicated sampling devices may not be practical if there are a large number of groundwater samples to be collected. In this case, sampling devices should be cleaned between sampling events using the decontamination procedures outlined in E & E Standard Operating Procedure for *Equipment Decontamination* (ENV 3.15).

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4. Sample Preservation, Containers, Handling, and Storage

The type of analysis for which a sample is being collected determines the type of bottle, preservative, holding time, and filtering requirements (see Table 1). Chemical preservation and cooling of samples to 4 degrees Celcius only retards biological and chemical degradation of contaminants in the sample. Therefore, it is prudent to have the samples delivered to the laboratory as soon as possible following collection.

Sample containers should be precleaned in accordance with U.S. Environmental Protection Agency (EPA) standards and prelabeled, and preservatives should be placed in the containers prior to sample collection. When filling containers, never overfill or prerinse with the water sample, since oil or other substances may remain in the container. For analyses that may require filtered samples (e.g., metals and TOC), the samples should be filtered in the field using one 0.45-micrometer (μm) membrane filter per sample container prior to being preserved.

When all samples have been collected, a field data sheet and a chain-of-custody (C-O-C) form should be completed, and all pertinent data entered in the field logbook. Samples will be placed in a cooler to be maintained on ice at 4 degrees Celcius. Samples must be shipped to arrive at the designated laboratory well before their holding times are reached. It is preferable that these samples be shipped or delivered daily to the laboratory as outlined in the E & E Standard Operating Procedure for *Sample Packaging and Shipping* (ENV 3.16).

5. Potential Problems

5.1 General

The primary goal is to obtain a representative analysis of the groundwater body. The analysis can be compromised by field personnel in two primary ways: by collecting an unrepresentative sample, and by incorrect handling of the sample. There are numerous ways that foreign contaminants can be introduced into the sample, and these must be avoided by following strict sampling procedures and utilization of trained personnel.

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Table 1				
SW-846 SAMPLE HOLDING TIMES, PRESERVATION METHODS, AND VOLUME REQUIREMENTS FOR WATER SAMPLES				
Protocol Parameter	Holding Time	Minimum Volume	Container Type	Preservation
VOA	14 days from date sampled	One 40-ml vial; no air space	Two 40-ml vials	Add HCl until pH <2 and ice to 4 °C
Semi-VOA (BNAs)	7 days to extract from date sampled	One 1-L jar	1/2-gallon amber glass bottle	Ice to 4 °C
PCBs	7 days to extract from date sampled	One 1-L jar	1/2-gallon amber glass bottle	Ice to 4 °C
Pesticides and PCBs	7 days to extract from date sampled	One 1-L jar	1/2-gallon amber glass bottle	Ice to 4 °C
Metals	6 months from date sampled	One 300-ml bottle	1-L poly bottle	Add HNO ₃ until pH <2 and ice to 4 °C
Cyanide	14 days from date sampled	One 100-ml bottle	1-L poly bottle	Add NaOH until pH >12 and ice to 4 °C
Hexavalent chromium	24 hours from time sampled	One 50-ml bottle	125-ml poly bottle	Ice to 4 °C
TOC	28 days from date sampled	One 10-ml bottle	125-ml poly bottle	Add H ₂ SO ₄ until pH <2 and ice to 4 °C
TOX	7 days from date sampled	One 200-ml bottle	1-L amber glass bottle	Add H ₂ SO ₄ until pH <2 and ice to 4 °C
TRPHs	28 days from date sampled	One 1-L bottle	1-L amber glass bottle	Add H ₂ SO ₄ until pH <2 and ice to 4 °C



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5.2 Purging

In a nonpumping well, there will be little or no vertical mixing of the water, and stratification will occur. The well water in the screened interval will mix with the groundwater due to normal flow patterns, but the water above the screened interval will remain isolated and become stagnant. Sampling team members should realize that stagnant water may contain foreign material inadvertently or deliberately introduced from the surface. To safeguard against collecting nonrepresentative stagnant water in a sample, the following guidelines and techniques should be adhered to during well purging and sampling:

- As a general rule, all monitoring wells should be pumped or bailed prior to the collection of the sample. Evacuation of a minimum of one volume of water in the well casing, and preferably three to five volumes, is recommended for a representative sample. In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, evacuation prior to sample collection is not as critical. However, in all cases where the monitoring data are to be used for enforcement actions, evacuation is recommended.
- For wells that can be pumped or bailed dry, the well should be evacuated and allowed to recover prior to sample withdrawal. If the recovery rate is fairly rapid and time allows, evacuation of more than one volume of water is preferred.
- A nonrepresentative sample can also result from excessive pumping of the monitoring well. Stratification of the leachate concentrations in the groundwater formation may occur or compounds that are heavier than water may sink to the lower portions of the aquifer. Excessive pumping can dilute or increase the contaminant concentrations from what is representative of the sampling point of interest.

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Table 2**ADVANTAGES AND DISADVANTAGES OF VARIOUS
GROUNDWATER SAMPLING DEVICES**

Device	Advantages	Disadvantages
Bailer	<ul style="list-style-type: none">• The only practical limitations are size and materials• No power source needed• Portable• Inexpensive; it can be dedicated and hung in a well, reducing the chances of cross-contamination• Minimal outgassing of volatile organics while sample is in bailer• Readily available• Removes stagnant water first• Rapid, simple method for removing small volumes of purge water	<ul style="list-style-type: none">• Time consuming, especially for large wells• Transfer of sample may cause aeration
Submersible Pump	<ul style="list-style-type: none">• Portable; can be used on an unlimited number of wells• Relatively high pumping rate (dependent on depth and size of pump)• Generally very reliable; does not require priming	<ul style="list-style-type: none">• Potential for effects on analysis of trace organics• Heavy and cumbersome, particularly in deeper wells• Expensive• Power source needed• Susceptible to damage from silt or sediment• Impractical in low-yielding or shallow wells
Non-Gas Contact Bladder Pump	<ul style="list-style-type: none">• Maintains integrity of sample• Easy to use	<ul style="list-style-type: none">• Difficult to clean, although dedicated tubing and bladder may be used• Only useful at depths down to approximately 100 feet• Supply of gas for operation (bottled gas and/or compressor) is difficult to obtain and is cumbersome
Suction Pump	<ul style="list-style-type: none">• Portable, inexpensive, and readily available	<ul style="list-style-type: none">• Only useful at depths down to approximately 25 feet• Vacuum can cause loss of dissolved gases and volatile organics• Pump must be primed and vacuum is often difficult to maintain• May cause pH modification
Inertia Pump	<ul style="list-style-type: none">• Portable, inexpensive, and readily available• Rapid method for purging relatively shallow wells	<ul style="list-style-type: none">• Only useful at depths down to approximately 70 feet• May be time consuming to use• Labor-intensive• WaTerra pump is only effective in 2-inch diameter wells

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5.3 Materials

The material used to construct groundwater purging and sampling devices can have a significant impact on the analytical results. If practical, equipment that contacts the groundwater should be constructed from stainless steel, teflon, or glass. The use of plastic should be avoided when analyzing for organics. Table 2 discusses the advantages and disadvantages of groundwater sampling devices, and Table 3 provides a ranking of sample material compatibility under various aqueous environments.

Table 3							
RELATIVE COMPATIBILITY OF RIGID GROUNDWATER SAMPLING MATERIALS							
	PVC I	Galvanized Steel	Carbon Steel	Low-carbon Steel	Stainless Steel 304	Stainless Steel 316	Teflon
Buffered Weak Acid	100	56	51	59	97	100	100
Weak Acid	98	59	43	47	96	100	100
Mineral Acid/High Solids	100	48	57	60	80	82	100
Aqueous/Organic Mixtures	64	69	73	73	98	100	100
Percent Overall Rating	91	58	56	59	93	96	100

Preliminary Ranking of Rigid Materials:

Teflon
Stainless Steel 316
Stainless Steel 304
PVC I
Low-Carbon Steel
Galvanized Steel
Carbon Steel



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6. Equipment Checklist

6.1 General

- Water level indicator (e.g., electric sounder, steel tape, transducer, reflection sounder, air line, etc.);
- Depth sounder;
- Appropriate keys for well cap locks;
- Steel brush;
- Organic vapor analyzer (OVA) or photo-ionization meter (HNu);
- Oil/water interface indicator (if necessary);
- Timepiece (preferably a stopwatch);
- Logbook;
- Calculator;
- Field data sheets;
- Bottle labels;
- Chain-of-custody forms;
- Custody seals;
- Sample containers;
- Engineer's rule;
- Sharp knife (locking blade);
- Tool box (screwdrivers, pliers, hacksaw, hammer, flashlight, adjustable wrench, bolt cutters, etc.);
- Leather work gloves;
- Appropriate personnel protection equipment;



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- 5-gallon pails;
- Plastic sheeting;
- Sealable plastic bags;
- Shipping containers;
- Packing material;
- U.S. Department of Transportation (DOT) shipping labels;
- 55-gallon 1A2 (17-H) drums (if necessary);
- Decontamination solutions;
- Tap water;
- Non-phosphate soap;
- Aluminum foil;
- Garden sprayers;
- Brushes;
- Preservatives; and
- Distilled or deionized water, as necessary.

6.2 Groundwater Sampling Devices

Bailers

- Clean decontaminated bailers of appropriate size and construction material;
- Nylon line (enough to dedicate to each well);
- Sharp knife;
- Aluminum foil (to wrap clean bailers);



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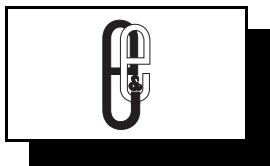
- Submersible pumps;
- Pump(s);
- Adequate power supply, generator, or battery;
- 1-inch black poly vinyl chloride (PVC) coil pipe (enough to dedicate to each well);
- Hose clamps;
- Safety cable (i.e., heavy-grade nylon line);
- Tool box supplement (pipe wrenches, wire strippers, electric tape, heat shrink, hose connectors, teflon tape);
- Winch or pulley (if desired);
- Gasoline for generator;
- Flow meter with gate valve; and
- 1-inch nipples and various pipe connectors.

Bladder Pumps

- Non-gas contact bladder pump;
- Compressor or nitrogen gas bottles;
- Batteries and charger;
- Teflon tubing (enough to dedicate to each well);
- Swagelock fitting; and
- Toolbox supplement (same as submersible pump).

Suction Pump

- Pump;
- Black coil pipe tubing (enough to dedicate to each well);



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- Gasoline (if required);
- Toolbox supplement (same as submersible pump);
- Various hose connectors and nipples; and
- Flow meter with gate valve.

7. Preparation

7.1 Office Preparation

- The preparation of a Site-Specific Safety Plan (SSSP) is required prior to any sampling. The SSSP must be approved and signed by the Corporate Health and Safety Officer or designee (i.e., the Regional Safety Coordinator [RSC]);
- Prepare a Site-Specific Work Plan (SSWP) to meet the data quality objectives of the project in accordance with contract requirements. Review available background information (e.g., topographic maps, hydrogeologic maps, geologic maps, other site reports, etc.) to determine the extent of the sampling effort, the sampling method to be employed, and the type and amounts of equipment and supplies required;
- Obtain necessary sampling and monitoring equipment (see Section 6), preclean the sampling equipment, and ensure that it is in proper working order;
- Ensure that batteries are charged, including the OVA, HNu, pump control box, and large storage batteries;
- Locate local sources for preservatives and decontamination solutions. Review this matter with the RSC or site safety coordinator;
- Contact delivery service to confirm ability to ship all equipment and samples. Determine if shipping restrictions exist; and
- Prepare schedules and coordinate with staff, clients, and regulatory agencies, if appropriate.


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7.2 Field Preparation

- Identify local suppliers of expendable sampling equipment such as ice and baggies, and overnight delivery services;
- Inspect all sampling equipment and reclean, if necessary, prior to groundwater sampling (see Table 4);
- A general site survey should be performed prior to site entry in accordance with the SSSP followed by a site safety meeting; and
- Identify all well locations.

Table 4		
DECONTAMINATION SOLUTIONS		
Type of Hazard	Name of Solution	Remarks
Amphoteric-acids and bases	Sodium bicarbonate	5-15% aqueous solution
Inorganic acids, metal processing wastes, heavy metals	Sodium carbonate	Good water softener, 10-20% aqueous solution
Solvents and organic compounds, oily, greasy unspecified wastes	Trisodium phosphate	Good rinsing solution of detergent, 10% aqueous solution
Pesticides, fungicides, cyanides, ammonia, and other non-acidic inorganic wastes	Calcium hypochlorite	Excellent disinfectant, bleaching and oxidizing agent, 10% aqueous solution
Other Types of Decontamination Solutions		
Other Detergents and Aqueous Surfactants		
Phosphate-free laboratory detergent (Alconox, Liquinox), Pennsalt 91, Oakite, Gunk, Clorox		
Solvents		
1,1,2-Trichloroethane, H ₂ -ethyl-hexyl acetate, pesticide-grade isopropanol/acetone/methanol/hexane, heptane (nonhydrogen bonding), alcohol, diesel fuel, naphtha, beta-propiolactone, carbon tetrachloride, 8% formalinethylene, 8% hexachloromelamine, 1,2-dichloroethane (in solution), Quadcoat		
Other Solutions		
10% nitric acid, 0.1 N/10%/20% hydrochloric acid		
Water		
Potable/tap water (demonstrated to be analyte-free), distilled water, deionized water, reagent-grade distilled and deionized water		

Source: Adapted from Devinny *et al.* 1990; Mickam *et al.* 1989.



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8. Reagents

Except for decontamination solutions and sample preservatives, there are no reagents required for these procedures. Refer to E & E Standard Operating Procedure for *Equipment Decontamination* (ENV 3.15), the SSSP, or the SSWP for proper decontamination procedures and appropriate solvents.

9. Field Sampling Procedures

9.1 Sampling Preparation

- Start at the least-contaminated well, if known;
- Remove locking well cap. Note the location of the well, time of day, and date in the field logbook or sample log;
- Remove the well cap covering the well riser;
- Test the well for volatile organic compounds (VOCs) and methane by conducting a headspace analysis with a combustible gas indicator, an OVA (for VOCs and methane), or an HNu (for VOCs). Record all readings in the field logbook;
- Lower water level measuring device into well until the surface of the water table is encountered;
- Measure the distance from the top of the water table to a reference point on the well riser or casing (e.g., top of inside casing [TOIC]) and record the distance in the field logbook;
- Lower the water level measuring device to the bottom of the well, and measure the total depth of the well using the same reference point on the well riser or casing. Record the distance in the field logbook.
- Measure the diameter of the well, and calculate the volume of water in the well by multiplying the number of feet of water by the number of gallons per foot (see Section 10);
- Determine the required volume of groundwater to be removed from the well (e.g., three well volumes or as indicated in the SSWP);



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- Place plastic sheeting on the ground around the well to minimize the likelihood of contamination of sampling equipment from soil adjacent to the well; and
- Prepare the purging and sampling equipment.

9.2 Purging

The amount of flushing that a well receives prior to sample collection depends on the intent of the monitoring program, as well as the hydrogeologic conditions. Programs in which overall quality determinations of water resources are involved may require long pumping periods to obtain a sample that is representative of the groundwater. The pumped volume can be determined prior to sampling, or the well can be pumped until selected parameters (e.g., temperature, electrical conductance, pH, turbidity, etc.) have stabilized. Care must be taken not to exceed the recommended purging rate for monitoring well screens (see Table 5).

Monitoring for defining a contaminant plume requires a representative sample of a small volume of the aquifer. These circumstances require that the well be pumped enough to remove the stagnant water, but not enough to induce flow from other areas.

During purging, water level measurements may be taken regularly at 15- and 30-second intervals. The data may be used to compute water table or aquifer transmissivity and other hydraulic characteristics.

Information on the most commonly used groundwater purging and sampling devices can be found in E & E's SOP for *Groundwater Sampling Devices* (ENV 3.6).

9.2.1 Bailers

Equipment needed will include a clean decontaminated bailer, nylon line, a sharp knife, and plastic sheeting. Place the plastic sheeting around the well to prevent contact of the bailer or line with the ground. Attach the line to the bailer, and then lower the bailer until it is completely submerged. Pull the bailer out of the well; ensure that the line either falls onto the plastic sheeting or never touches the ground. Empty the bailer into a 5-gallon pail. Repeat the procedure until the required purge volume has been removed. When the 5-gallon pail is full, pour the water into a 55-gallon drum or handle as indicated in the SSWP.

9.2.2 Submersible Pumps

- Assemble the pump, hose, and safety cable;
- Lower the pump and assembly into the monitoring well to a point a few feet below the water level;
- Attach to a power source and commence purging operations;


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Table 5
MAXIMUM RECOMMENDED PURGING RATE FOR MONITORING WELL SCREENS

Screen Type	Diameter (in)	Slot (in)	Open Area (ft ² /ft)	Open Area (%)	Recommended Pumping Rate		
					gpm/ft at 0.1 ft/s	gpm/ft at 0.07 ft/s	gpm/ft at 0.03 ft/s
PVC (machine slot)	2	0.01	0.018	3.4	0.804	0.563	0.241
	2	0.02	0.033	6.4	1.496	1.047	0.449
	2	0.025	0.042	8.0	1.870	1.309	0.561
	2	0.04	0.060	11.5	2.693	1.885	0.808
	2	0.051	0.075	14.4	3.385	2.369	1.015
	4	0.01	0.036	3.4	1.608	1.126	0.482
	4	0.02	0.067	6.4	2.992	2.094	0.898
	4	0.025	0.083	8.0	3.740	2.618	1.122
	4	0.04	0.120	11.5	5.386	3.770	1.616
	4	0.051	0.151	14.4	6.773	4.741	2.032
PVC (wound)	2	0.01	0.047	9.0	2.119	1.484	0.636
	2	0.02	0.089	17.0	3.989	2.793	1.197
	2	0.03	0.124	23.7	5.579	3.905	1.674
	2	0.04	0.156	29.7	6.981	4.887	2.094
	2	0.05	0.183	34.9	8.197	5.738	2.459
	4	0.01	0.078	7.5	3.522	2.465	1.057
	4	0.02	0.147	14.1	6.607	4.625	1.982
	4	0.03	0.208	19.9	9.350	6.545	2.805
	4	0.04	0.262	25.0	11.750	8.225	3.525
	4	0.05	0.309	29.5	13.869	9.708	4.161
Stainless Steel (wire-wound)	2	0.01	0.090	17.1	4.021	2.814	1.206
	2	0.02	0.157	30.0	7.044	4.931	2.113
	2	0.03	0.210	40.2	9.444	6.610	2.833
	2	0.04	0.253	48.4	11.376	7.963	3.413
	2	0.05	0.287	54.8	12.872	9.010	3.862
	4	0.01	0.177	16.9	7.948	5.563	2.384
	4	0.02	0.307	29.3	13.776	9.643	4.133
	4	0.03	0.410	39.1	18.388	12.872	5.517
	4	0.04	0.492	47.0	22.097	15.468	6.629
	4	0.05	0.560	53.4	25.120	17.584	7.536



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- Using a flow meter or pail and a stopwatch, determine the flow rate and calculate the time required to remove the required volume of water from the well;
- Place the purge water in 55-gallon drums or handle as indicated in the SSWP; and
- Lower the pump by stages until it is just above the screen, and continue to purge until the required volume of water has been removed from the well. In cases where the well will not yield water at a sufficient recharge rate, pump the well dry and allow it to recover.

9.2.3 Non-Gas Contact Bladder Pumps

- Assemble the teflon tubing, pump, and charged control box;
- Procedures for purging with a bladder pump are the same as for a submersible pump (Section 9.2.2); and
- Be sure to adjust the flow rate to prevent violent jolting of the hose.

9.2.4 Suction Pumps

- Assemble the pump, tubing, and power source; and
- Procedures for purging with a suction pump are the same as for a submersible pump (Section 9.2.2).

9.3 Sampling

Groundwater samples can be obtained through the use of a number of groundwater sampling devices. Each groundwater sampling device has its advantages (and disadvantages) over other devices. Ideally, groundwater sampling devices should be completely inert, economical to manufacturer, easily cleaned for reuse, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for both well purging and sample collection. There are several other factors to consider when choosing a groundwater sampling device and care should be taken when selecting the device. Refer to the E & E Standard Operating Procedure for Groundwater Sampling Devices (ENV 3.6) for additional information.

9.3.1 Bailers

- Make sure that clean plastic sheeting has been placed around the well;



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- Attach a line to the bailer. If a bailer was used for purging, the same bailer and line may be used for sampling;
- Lower the bailer slowly and gently into the well, taking care not to shake the well casing or splash the bailer into the water. Lower the bailer to different points adjacent to the well screen to ensure that a representative water sample is collected;
- Slowly and gently retrieve the bailer from the well, avoiding contact with the well riser;
- Remove the cap from a sample container and place the cap on plastic sheeting or in a location where it will not be contaminated. Refer to Section 9.6 for special considerations for volatile organic analysis (VOA) samples;
- Slowly pour the water into the container;
- Filter and preserve samples as required by the SSWP. Mark the water level on the container with a pen;
- Prepare the necessary QA samples as outlined in the SSWP;
- Record sample information in the field logbook or on field data sheets, and complete the C-O-C form;
- Package samples in accordance with the SSWP; and
- Repeat this process until all groundwater samples have been collected.

9.3.2 Submersible Pumps

- Allow the monitoring well to recharge after purging, keeping the pump just above the screened interval;
- Attach a gate valve to the discharge hose, and reduce the flow rate to a manageable sampling rate;
- Prepare the sample containers;
- If no gate valve is available, discharge the sample into a clean jar and fill the sample containers from the jar;



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- Complete the sampling and documentation procedures as outlined in Section 9.3.1; and
- Upon completion, remove the pump and assembly and properly decontaminate the pump prior to use in the next well. Do not reuse the discharge tubing.

9.3.3 Bladder Pump

- Allow the well to recharge after purging;
- Prepare the sample containers;
- Turn the pump on. Increase the cycle time and reduce the pressure to the minimum that will allow groundwater to come to the surface;
- Complete the sampling and documentation procedures as outlined in Section 9.3.1;
- Upon completion, remove the tubing from the well and either replace the teflon tubing and bladder with new dedicated tubing and bladder, or properly decontaminate the existing material;
- Nonfiltered groundwater samples should be collected directly from the outlet tubing into the sample containers; and
- Filtered groundwater samples should be obtained by connecting the pump outlet tubing directly to the filter unit. The pump pressure should be reduced to prevent a pressure buildup on the filter, which could damage the pump bladder.

9.3.4 Suction Pumps

- Allow the well to recharge;
- Attach a gate valve to the discharge line if the suction pump discharge rate cannot be controlled, or discharge the sample into a clean glass jar and fill the sample containers from the jar;
- Sample as outlined in Section 9.3.1; and
- Upon completion, remove the tubing and properly decontaminate the pump prior to use in the next well. Do not reuse the tubing.

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9.4 Filtering

Samples being analyzed for total dissolved metals and total organic carbons (TOC) may require filtering. Two types of filters are commonly used: barrel filters and vacuum filters. A barrel filter works with a bicycle pump, which is used to build up positive pressure in the chamber containing the sample. Water is then forced through 0.45- μ m filter paper into a jar. The barrel itself is filled manually.

A vacuum filter involves two chambers: the upper chamber contains the sample, and a 0.45- μ m filter divides the two chambers. Using a portable vacuum pump, air is withdrawn from the lower chamber, creating a vacuum, which causes the sample to move through the filter into the lower chamber. Repeated pumping may be required to drain all of the sample into the lower chamber. If preservation of the samples is necessary, this should be done after filtering.

9.5 Post-Operation

After all samples have been collected and preserved, the sampling equipment should be properly decontaminated to prevent cross-contamination of samples.

- Decontaminate all equipment according to the SSWP;
- Replace sampling equipment in storage containers;
- Prepare groundwater samples for shipment. Check sample documentation and make sure samples are properly packed for shipment; and
- Organize field notes into a report format and transfer logging information to appropriate forms.

9.6 Special Consideration for VOA Sampling

The proper collection of a sample for dissolved VOCs requires minimal disturbance of the sample to limit volatilization and subsequent loss of volatiles from the sample.

Sample retrieval systems suitable for the valid collection of volatile organic samples include: positive-displacement bladder pumps, gear-driven submersible pumps, and syringe samplers and bailers. Field conditions and other constraints will limit the choice of appropriate systems. The principal objective is to provide a valid sample for analysis that has been subjected to the least amount of turbulence possible.

The following procedures should be followed when collecting VOA samples:

- Open the vial, set the cap in a clean place, and place the proper amount of preservatives (HCl) in the vial;
- Fill the vial to the top until a convex meniscus forms on the top of the vial. Do not overfill the vial;



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- Check that the cap has not been contaminated, and carefully cap the vial. Place the cap directly over the top and screw down firmly. Do not overtighten and break the cap;
- Invert the vial and tap gently. If an air bubble appears, discard the sample and begin again. It is imperative that no entrapped air remains in the sample vial;
- Place the VOA vial in a cooler, oriented so that it is lying on its side, not straight up; and
- The holding time, under most protocol parameters, for VOAs is 14 days (see Table 1). It is recommended that samples be shipped or delivered to the laboratory daily. Ensure that the samples remain at 4°C, but do not allow them to freeze.

10. Calculations

Table 6 presents the volume of water in different size casings and holes. To determine the volume of water in a well, the calculations are as follows:

$$V = Tr^2(0.163)$$

where:

V = Static volume of well in gallons

T = Depth of water in well, measured in feet (determined by subtracting the static water level from the total depth of the well)

r = Inside radius of well casing, measured in inches

0.163 = A constant conversion factor for the conversion of the casing radius from inches to feet and cubic feet to gallons


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Table 6
VOLUME OF WATER IN CASING OR HOLE

Diameter of Casing or Hole (in)	Gallons per Foot of Depth	Cubic Feet per Foot of Depth	Liter per Meter of Depth	Cubic Meters per Meter of Depth
1	0.041	0.0055	0.509	0.509×10^{-3}
1.5	0.092	0.0123	1.142	1.142×10^{-3}
2	0.163	0.0218	2.024	2.024×10^{-3}
2.5	0.255	0.0341	3.167	3.167×10^{-3}
3	0.367	0.0491	4.558	4.558×10^{-3}
3.5	0.500	0.0668	6.209	6.209×10^{-3}
4	0.653	0.0873	8.110	8.110×10^{-3}
4.5	0.826	0.1104	10.260	10.260×10^{-3}
5	1.020	0.1364	12.670	12.670×10^{-3}
5.5	1.234	0.1650	15.330	15.330×10^{-3}
6	1.469	0.1963	18.240	18.240×10^{-3}
7	2.000	0.2673	24.840	24.840×10^{-3}
8	2.611	0.3491	32.430	32.430×10^{-3}
9	3.305	0.4418	41.040	41.040×10^{-3}
10	4.080	0.5454	50.670	50.670×10^{-3}
11	4.937	0.6600	61.310	61.310×10^{-3}
12	5.875	0.7854	72.960	72.960×10^{-3}
14	8.000	1.0690	99.350	99.350×10^{-3}
16	10.440	1.3960	129.650	129.650×10^{-3}
18	13.220	1.7670	164.180	164.180×10^{-3}
20	16.320	2.1820	202.680	202.680×10^{-3}
22	19.750	2.6400	245.280	245.280×10^{-3}
24	23.500	3.1420	291.850	291.850×10^{-3}
26	27.580	3.6870	342.520	342.520×10^{-3}
28	32.000	4.2760	397.410	397.410×10^{-3}
30	36.720	4.9090	456.020	456.020×10^{-3}
32	41.780	5.5850	518.870	518.870×10^{-3}
34	47.160	6.3050	585.680	585.680×10^{-3}
36	52.880	7.0690	656.720	656.720×10^{-3}

1 Gallon = 3.785 liters

1 Meter = 3.281 feet

1 Gallon water weighs 8.33 lbs. = 3.785 kilograms

1 Liter water weighs 1 kilogram = 2.205 pounds

1 Gallon per foot of depth = 12.419 liters per foot of depth

1 Gallon per meter of depth = 12.419×10^{-3} cubic meters per meter of depth



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11. Quality Assurance/Quality Control

The objective of QA/QC is to identify and implement methodologies that limit the introduction of error into sampling and analytical procedures. Groundwater sampling protocols appropriate to the data quality objectives and site conditions will define the specific procedures that will be followed for sampling events (see Figure 1).

There are seven primary areas of concern for QA in the collection of representative groundwater samples:

- The SSWP should be reviewed by all team personnel involved in the collection of the groundwater samples before any sampling is attempted, with attention to contaminant type and potential concentration variations;
- Log documentation should be reviewed to determine whether the required volume of purge water was removed from the well and that the temperature, electrical conductance, and pH had been stabilized to ensure that a representative water sample of the aquifer was obtained;
- The purging and sampling devices should be made of materials and utilized in a manner that will not interact with or alter the analysis;
- The results generated by these procedures are reproducible as demonstrated through the use of duplicate samples;
- The possibility of cross-contamination is reduced by collecting samples from the least contaminated well first. Rinsate blanks should be incorporated where dedicated sampling and purging equipment is not utilized and decontamination of the equipment between sampling events is required;
- Samples are properly labeled, documented (C-O-C), preserved, and shipped; and
- A record of daily field activities, such as sample collection and tracking information, is kept in a bound book.

12. Data Validation

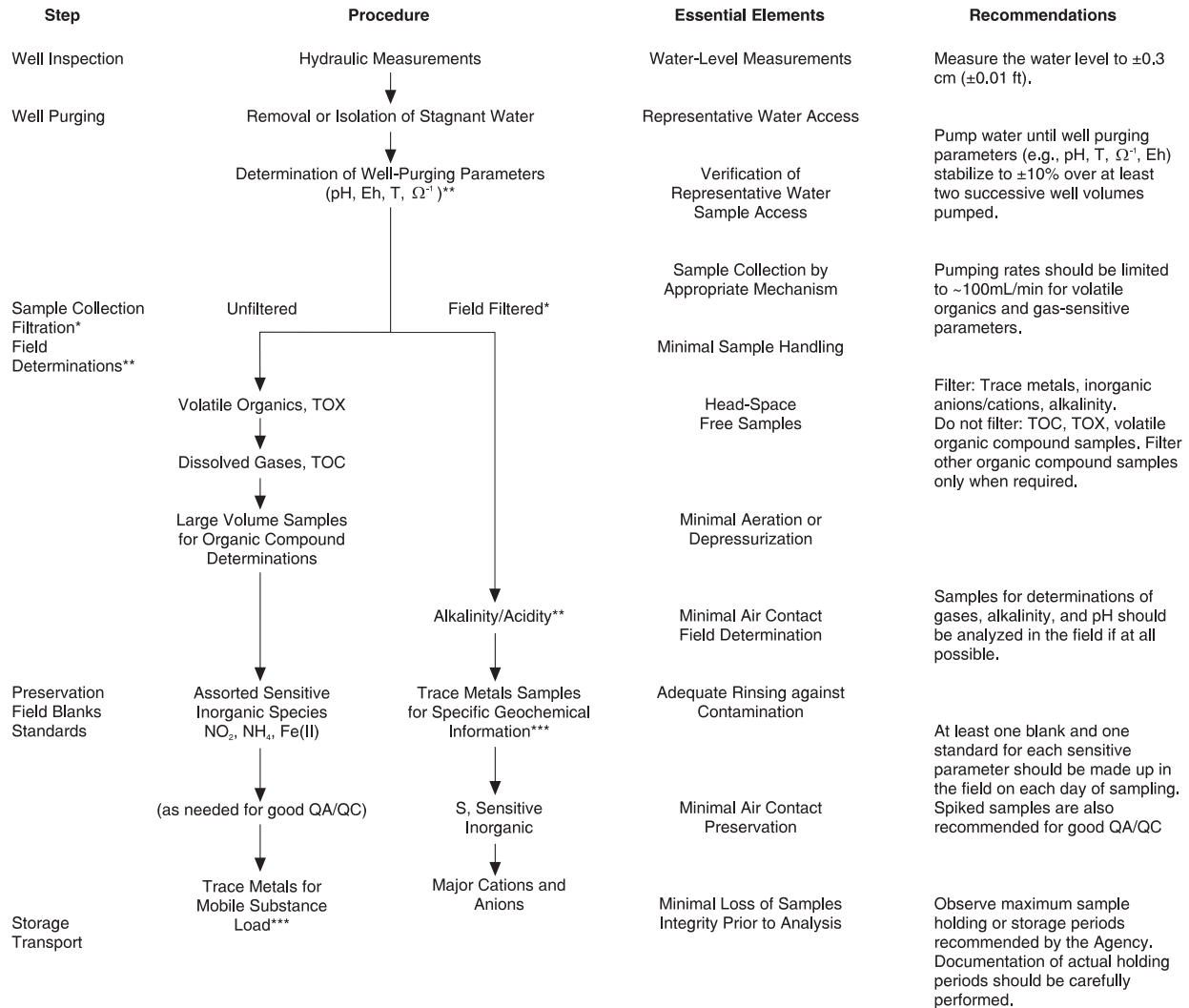
The data generated will be reviewed according to the QA/QC considerations presented in Section 11.

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* Denotes samples that should be filtered to determine dissolved constituents. Filtration should be accomplished preferably with in-line filters and pump pressure or by N_2 pressure methods. Samples for dissolved gases or volatile organics should not be filtered. In instances where well development procedures do not allow for turbidity-free samples and may bias analytical results, split samples should be spiked with standards before filtration. Both spiked samples and regular samples should be analyzed to determine recoveries from both types of handling.

** Denotes analytical determinations that should be made in the field.

See Puls and Barcelona (1989).

Figure 1 Generalized Flow Diagram of Groundwater Sampling Protocol

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13. Health and Safety

Depending on the site-specific contaminants, the type of personnel protective equipment (PPE) used during the purging and sampling of the wells is outlined in the SSSP. The SSSP should be reviewed with specific emphasis placed on the safety procedures to be followed for the well sampling tasks. Standard safe operating practices should be followed, such as minimizing contact with potential contaminants in both the vapor phase and liquid matrix through the use of respirators and protective clothing.

14. References

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TITLE:		GROUNDWATER WELL SAMPLING	
CATEGORY:	ENV 3.7	REVISED:	March 1998

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TITLE:

MEASURING WATER LEVEL AND WELL DEPTH

CATEGORY:

GEO 4.15

REVISED:

March 1998

STANDARD OPERATING PROCEDURE

MEASURING WATER LEVEL AND WELL DEPTH

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**TITLE:****MEASURING WATER LEVEL AND WELL DEPTH****CATEGORY:****GEO 4.15****REVISED:****March 1998**

1. Scope and Application

This document describes E & E's standard operating procedure (SOP) for measuring water level and well depth in monitoring wells and piezometers.

2. Equipment

The following is a list of equipment and items typically used for measuring water level and well depth:

- Electronic water level indicator with graduated cable measured at increments of 0.1 and 0.01 foot;
- Plastic sheeting; and
- Folding ruler or pocket steel tape.

3. Procedure

3.1 Preliminary Steps

1. Locate the well or piezometer and verify its position on the site map. Record whether positive identification was obtained, including the well number and any identifying marks or codes contained on the well casing or protective casing. Gain access to the top of the well casing and note the date and time the well was opened. If specified in the work plan or site health and safety plan, use monitoring equipment to measure or take readings of the well headspace. Record all measurements and observations (e.g., odor).

2. Locate and record the specified benchmark or survey point for the well or piezometer, which may be a mark at the top of the casing or a surveyor's pin embedded in the protective structure. Determine the elevation of this point from the records and record in the notebook. Measure and record the vertical distance from the benchmark to the top of the well casing to the nearest 0.01 foot. Measure and record the metal casing stickup (i.e., the distance between the top of the casing and nominal ground level).

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3. Record any observations and remarks regarding the completion characteristics and well condition, including evidence of cracked casing or surface seals, security of the well (locked cap), and evidence of tampering.
4. Keep all equipment and supplies protected from contamination with clean plastic sheeting. Keep the water level indicator probe in its protective case when not in use.

3.2 Operation

1. Remove the water level indicator probe from the case, turn on the sounder, and test-check the battery and sensitivity scale by pushing the red button. Adjust the sensitivity scale until you can hear the buzzer and see the red indicator light.
2. Slowly lower the probe and cable into the well, allowing the cable reel to unwind. Continue lowering until the meter buzzes. Raise and lower the probe very slowly until the meter begins to buzz continuously. Mark the spot by grasping the cable with the thumb and forefingers at the top of the casing, withdraw the cable, and record the depth.
3. To measure the total well or piezometer depth, lower the probe until slack is felt in the cable. Very slowly raise and lower the cable until the exact bottom of the well is detected. As before, grasp the cable with the thumb and forefinger at the top of the casing and note the depth. If a water level probe, such as the Solinst, is used to measure total depth, the weight of the probe will likely extend approximately 6 centimeters beyond the calibrated "zero" point of the measuring cable. If this is the case, use the cable to accurately measure the distance from the end of the weight to the point of the needle (in the "window" of the probe) and add this length to the depth noted above. Record the sum of these two lengths as the total depth of the well.
4. Withdraw the cable and probe, and decontaminate according to the SOP for Equipment Decontamination (ENV 3.15).

3.3 Data Recording and Manipulation

Record the following computations:

- Casing elevation = bench mark elevation + casing stickup
- Water level elevation = casing elevation - depth of water
- Well bottom elevation = casing elevation - depth to bottom
- Total well depth = cable-measured depth + length of the weight extension



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4. Calibration

No calibration is needed for the electronic water level indicator.

5. Precautions

Because some casings have rough or sharp edges, use caution when lowering and retrieving the water level cable from within the well casing. These edges can cut and scrape the cable, obscuring the calibrated markings on the cable, and can eventually lead to failure (shorting out) of the electronic cable.

Always use caution when opening capped wells, because escaping (venting) headspace gases may be hazardous.

**TITLE:****EVALUATION OF EXISTING MONITORING WELLS****CATEGORY:****GEO 4.19****REVISED:****March 1998****STANDARD OPERATING PROCEDURE****EVALUATION OF EXISTING
MONITORING WELLS**

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1. Scope and Application

The purpose of this Standard Operating Procedure (SOP) is to delineate protocols for determining the validity of samples collected in existing monitoring wells and the utility of those wells for collecting additional samples.

2. Material

- a. Field logbook
- b. Indelible black ink pen
- c. Photoionization or flame ionization detector
- d. Electronic water level indicator
- e. Steel tape or folding ruler
- f. Flashlight
- g. Deionized or distilled water

3. Procedure

The following steps will help to insure that the required data are available to permit an evaluation of the utility of existing monitoring wells for collecting additional samples during site investigation activities.

- 1) Evaluate and review the original work plan for monitoring well installation, if available.
- 2) Review all available information concerning well construction. The physical features which must be identified and detailed, if available, include:
 - a. Well identification number, permit number and location by referenced coordinates or by distance from prominent site features;
 - b. Installation dates, drilling methods and contractors;
 - c. Depth to bedrock (if applicable). Where rock cores were not taken, auger refusal, drive casing refusal or penetration test results (blow counts for split-spoon sampling) may be used to estimate bedrock interface;



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- d. Soil profile and stratigraphy;
- e. Borehole depth and diameter;
- f. Elevation of collar and top of well riser;
- g. Depth of bottom of well;
- h. Type of well materials, screen type and length, and elevation of top and bottom of screen;
- i. Elevation of tops and bottoms of well seals and elevation of top and bottom of gravel or sand pack.

3) On-site inspection of existing monitoring wells. Features to be noted include:

- a. The condition of the protective casing, cap and lock;
- b. The condition of the cement pad surrounding the protective casing;
- c. The presence of depressions or standing water around the casing;
- d. The presence of any electrical cable and its connections.

4) Remove the lock and open the cap. Check for the presence of organic vapors with a PID meter to determine the appropriate worker safety level. The following information shall be recorded (preferably in the form of annotated sketches):

- a. Cap integrity;
- b. Physical characteristics and composition of the inner casing or riser, including inner diameter and annular space;
- c. Presence of grout between the riser and outer protective casing and the presence or absence of drain holes in the protective casing;
- d. Presence of riser cap, method of attachment to casing, and venting of the riser;
- e. Presence of dedicated sampling equipment; if possible, remove such equipment and inspect size, materials of construction and condition.



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TITLE:

MONITORING WELL INSTALLATION

CATEGORY:

GEO 4.10

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STANDARD OPERATING PROCEDURE

MONITORING WELL INSTALLATION

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1. Scope and Application

The installation of monitoring wells is contingent upon the existing conditions at the project site. The purpose of this Standard Operating Procedure (SOP) is to delineate the quality control measures required to ensure the accurate installation of monitoring wells. The applicable site Field Sampling Plan should be consulted for specific installation instructions. The term "monitoring wells" is used generically and includes observation wells and piezometers.

2. Materials

- a. Drilling Equipment (provided by subcontractor)
- b. Material required for well installation as specified in the Field Sampling Plan accompanying this submittal
- c. Hand Lens
- d. Weighted Tape
- e. Water Level Measuring Device
- f. E & E's Standard Geotechnical Log Book

3. Procedure

3.1 Materials

Screens, casings, and fittings will conform to National Sanitation Foundation Standard 14 or the American Society for Testing and Materials (ASTM) equivalent for potable water usage. These materials will bear the appropriate rating logo. If the logos are not present, a written statement from the manufacturer/supplier stating that the materials contain the appropriate rating must be obtained. Material used will be new and essentially chemically inert to the site environment.

Water sources for drilling, grouting, sealing, filter placement, well installation, and equipment decontamination must be approved by E & E prior to arrival of the drilling equipment. Information required for the water source includes: water source (hydrant no., if applicable), owner, address and telephone number, type of treatment and filtration prior to point of discharge, time of access, cost per gallon (if applicable), dates and results associated with all available chemical analyses over the past two years, and the name and address of the analytical laboratory (where applicable).

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Bentonite will be the only drilling fluid additive allowed unless otherwise specified in the project work plan. The use of any additives or materials must be approved by E & E and/or the governing regulatory agency prior to its implementation. The information required for evaluation includes: brand name, manufacturer, manufacturer's address and telephone number, product description, and intended use for the product.

Granular Filter Pack material must be approved by E & E prior to drilling. A one-pint representative sample must be supplied to E & E. Information required includes: lithology, grain size distribution, brand name, source, processing method, and slot size of intended screen.

3.2 Drilling

The hollow stem auger drilling method will be used for typical well installation. Air rotary methods using a rock bit will be used in hard lithologies. Any alterations to these methods will require prior approval by E & E, the client, and/or the governing regulatory agency.

A qualified Site Geologist will be present during all well drilling and installation activities, and will fully describe all tasks performed in support of these activities in the Geotechnical Log Book. A Site Geologist will be responsible at each rig for the logging of samples, monitoring of drilling operations, recording of water losses/gains and other observable groundwater data, preparing the boring logs and well diagrams, and recording the well installation procedures performed by the subcontractor.

Decontamination of all well installation equipment and construction material will be carried out as described in E & E's SOP for Equipment Decontamination (ENV 3.15)

Petroleum jelly, teflon tape, lithium grease, or vegetable-based lubricants shall not be used on the threads of downhole drilling equipment. Additives containing either lead or copper will not be allowed. In addition, polychlorinated biphenyls will not be contained in hydraulic fluids or other fluids used in the drilling rig, pumps, or other field equipment and vehicles. Surface runoff or other fluids will not be allowed to enter any boring or well during or after drilling/construction.

Antifreeze used to keep equipment from freezing during periods of cold weather and will not contain rust inhibitors and sealants. If the antifreeze is added in an area in contact with drilling fluid, the antifreeze will be completely purged from the equipment prior to use in drilling, mud mixing, or any integral part of the overall drilling operation. The contractor will note the following information in the boring log in regard to the use of antifreeze: date, reason, quantities, and brand name.

According to the Site Health and Safety Plan (HASP), monitoring of the borehole will be conducted at regular intervals using a photoionization detector or flame ionization detector to check for the presence of VOCs. Other screening methods may also be required according to the HASP.

3.3 Well Construction and Installation

The installation of monitoring wells will begin within 12 hours of boring completion for holes uncased or partially cased, and within 48 hours for holes fully cased with temporary drill casing or held open by auger. Once installation has begun, work will be continued until the well has been grouted and the drill casing has been removed. Exceptions must be requested in writing

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by the contractor to E & E prior to drilling. Unscheduled delays attributable to unforeseeable site occurrences will not require advance approval.

The construction of each well will be depicted in the well construction diagram contained within the Geotechnical Log Book. The diagram will remain attached to the borelog and will graphically denote the following components and their dimensions, where applicable:

- a. Protective casing detail
- b. Height of riser
- c. Grout
- d. Bentonite seal
- e. Granular filter pack
- f. Screen location
- g. Joint location
- h. Centralizers
- i. Cave-in
- j. Bottom of the boring

Screens, casings, and fittings will conform to the standards given in Section 3.1. All materials will be decontaminated prior to use and will be assembled without the use of lubricants, cements, or chemicals. The placement of all materials in the well boring will be observed and documented by the field geologist. Granular filter packs will be chemically and texturally clean, inert, siliceous, and of appropriate size.

Unless otherwise specified in the site-specific work plan (SSWP), or limited by site conditions, bentonite seals will be a minimum of two feet thick as measured immediately after placement. The final depth of the top of the bentonite seal will be measured and recorded in the Geotechnical Log Book. Any exceptions to the recommended thickness must be described in detail in the log. (Note: In order to prevent heaving, the top of a bentonite seal should not be less than 1.5 to 2 feet below ground surface.)

Unless otherwise required by the SSWP, grout used in construction will be composed by weight of:

- 20 parts cement (Portland cement, type II or V);
- 1 part bentonite; and
- 8-gallons (max) approved water per 94-lb bag of cement per 5 pounds of bentonite.

Neither additives nor borehole cuttings will be mixed with the grout. Bentonite will be added after the required amount of cement is mixed with the water. All grout material will be combined in an aboveground container and mechanically blended to produce a thick, lump-free mixture. The mixed grout will be recirculated through the grout pump prior to placement.

Grout placement will be performed using a commercially available grout pump and a rigid tremie pipe. The tops of all well casing will be telescopically capped with covers composed of

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materials compatible with the products used in the well installation. Caps will be constructed to preclude binding to the well casing caused by tightness of fit, unclean surfaces, or weather conditions, yet secure enough to preclude the introduction of foreign material into the well. In addition, caps will be loose enough to allow pressure equalization between the well and the atmosphere.

Well protective casings will be installed around all monitoring wells on the same day as the initial grout placement around the well. Any annulus formed between the outside of the protective casing and the borehole will be filled to ground surface with grout.

3.4 Monitoring Well Completion

Decontaminated well casing will be placed on polyethylene sheeting, and will not be allowed to touch the ground or any other object.

Assemble appropriate decontaminated lengths of casing and screen. Make sure these materials are clean and free of grease, soil, and residue.

Lower each section of casing and screen into the borehole, one at a time, screwing each section securely into the section below it. No grease, lubricant, glue, or teflon tape may be used in joining the pipe and screen sections. Rubber O-rings may be used to provide water-tight joint in wells of stainless steel construction.

When the well is set to the bottom of the borehole, temporarily place a cap on top of the casing to keep the well interior clean.

Place the appropriate filter pack material by gradually pouring it into the annular space through a tremie pipe. The tremie pipe should extend from the ground surface to the depth of the filter pack such that the material is added from the "bottom up." Monitor the rise of material in the annulus with a weighted tape to assure that bridging is not occurring.

After the filter pack is in place, wait three to five minutes for the material to settle. Remeasure the settled height of the filter pack and tremie more material, if necessary.

Install the bentonite seal by dropping bentonite pellets into the hole gradually, again monitoring for bridging with a weighted tape.

Wait 30 to 60 minutes for the bentonite pellets to hydrate and swell. If the pellets are above the water level in the hole, add several buckets of clean water to the boring. Document the amount and source of water added to the hole.

Mix a cement-bentonite slurry using clean water from an approved source, Portland Type II cement, and powdered bentonite. Be sure the mixture is thoroughly mixed and as thick as is practicable.

Lower a tremie pipe or hose into the annulus to the level of the bentonite pellet seal.

Pump the cement-bentonite slurry into the annulus while withdrawing the tremie pipe/hose. Continue filling the annulus with the slurry up to the ground surface.

Cut the riser casing off approximately 2 to 2.5 ft. above grade. Place a vented cap on the well.

Set the steel protective casing over the well and into the cement-bentonite slurry below the ground surface. Lock the cap.

Allow the cement-bentonite slurry to set overnight.



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After allowing the cement-bentonite slurry to set, fill the remainder of the annulus with neat cement. Form a cement apron around the protective casing.

3.5 Logging

All borings for monitoring wells will be logged by a geologist or engineer. Logs will be recorded in the Geotechnical Log Book and/or field log book. If the information is recorded in a field log book, it will be transferred to Boring Log Forms on a daily basis. Field notes are to include, as a minimum:

- a. Boring Number and Location
- b. Geological Material Description (as discussed below)
- c. Weather Conditions
- d. Possible Indications of Contamination During Drilling
- e. Groundwater Conditions (including measured water levels)
- f. Daily Drilling Footage and Quantities (for billing purposes)
- g. Drilling Method and Bore Hole Diameter
- h. Any Deviations from Established Work Plans
- i. Blow Counts for Standard Penetration Test
- j. Core and Split-Spoon Recoveries
- k. Name of Contractor, Driller and Rig Geologist
- l. Date and Time of Start and Completion of Each Boring
- m. Field Instrument Readings Such As HNu, OVA, etc.

Material description for soil samples must include:

- a. Classification
- b. Unified Soil Classification Symbol
- c. Secondary Components and Estimated Percentages
- d. Color
- e. Plasticity
- f. Consistency (if cohesive soil)
- g. Density (if non-cohesive soil)
- h. Moisture Content
- i. Texture/Fabric/Bedding and Orientation
- j. Grain Angularity
- k. Depositional Environment and Formation
- l. Presence of Calcium Carbonate (CaCO_3)
- m. Sample Recovery

Material description for rock samples must include:

- a. Classification
- b. Lithologic Characteristics

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- c. Bedding/Banding Characteristics
- d. Color
- e. Hardness
- f. Degree and Type of Cementation
- g. Presence of Calcium Carbonate (CaCO_3)
- h. Texture
- i. Structure and Orientation
- j. Degree of Weathering
- k. Solution or Void Conditions
- l. Primary and Secondary Permeability
- m. Sample Recovery
- n. Degree of Weathering and Friability

3.6 Well Development

Well development can be defined as the process by which drilling fluids, solids, and other mobile particulates within the vicinity of a newly installed monitoring well are removed thus restoring the inherent hydraulic conductivity of the aquifer. Well development will be initiated after 24 consecutive hours but not longer than seven calendar days following the completed installation of the surface protective casing of the well. A detailed record of the well development will be documented in the Geotechnical Log Book.

Materials required:

- Well Development Form (Geotechnical Log Book);
- Boring Log and Well Completion Diagram for the well (Geotechnical Log Book);
- Submersible pump, centrifugal pump, or bailer of appropriate capacity;
- pH, conductivity, and temperature meters;
- Electric well sounder and measuring tape; and
- Containers for purged water, if required.

Development of newly installed groundwater monitoring wells will be performed according to the following protocol. Development of monitoring wells will be recorded in the Geotechnical Log Book. The following development data will be recorded.

- a. Well designation
- b. Date of well installation
- c. Date of development
- d. Stable water level before and 24 hours after development

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- e. Quantity of water lost during drilling and fluid purging, if water is used
- f. Quantity of standing water in well and annulus (30 percent porosity for annulus material is assumed for calculation) prior to development
- g. Specific conductivity, turbidity, temperature, and pH measurements taken and recorded at the start of development, three or more times during, and at the conclusion of development. Calibration standards will be run prior to, during, and after each day's operation of instruments in the field
- h. Depth from top of well casing to bottom of well
- i. Screen length
- j. Depth from top of well casing to top of sediment inside well, before and after development
- k. Physical character of removed water, including changes during development in clarity, color, particulate matter, and odor
- l. Type and size/capacity of pump and/or bailer used
- m. Description of surge technique, if used
- n. Height of well casing above or below ground surface
- o. Quantity of water removed and removal time

Development of wells will be accomplished by pumping the groundwater with an electric-powered submersible or centrifugal pump until the water is clear and the well is free of sediment, to the fullest extent practical. If well yields cannot sustain the flow rate of the submersible pump and the water is sediment free to the fullest extent practical, a dedicated bailer will be used to evacuate the well. Water will not be added to the well to aid in development, nor will any type of airlift technique be used.

The pump, bailer and cable will be decontaminated by the procedures outlined in ENV 3.15. Unless otherwise specified in the SSWP, development water will be discharged on site or containerized and transported to a central storage area, in accordance with local regulatory guidance. Based on the analysis of groundwater samples collected from the monitoring wells, any containerized water will be disposed of in a manner which is in compliance with appropriate government regulations.

Development will proceed until the following conditions are met:

- a. Turbidity is <100 NTU, or parameters including pH, conductivity, and temperature have stabilized;
- b. The sediment thickness remaining in the well is less than 5 percent of the screen length;
- c. At least five well volumes (including the saturated filter material in the annulus) plus the volume of water added during the drilling process (if any) have been removed from the well; and



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- d. The cap and all internal components of the well casing above the water table have been rinsed with well water to remove all traces of soil/sediment/cuttings. Washing will also be conducted before and/or during development.

4. Maintenance

Not applicable.

5. Precautions

Refer to the site-specific Health and Safety Plan for discussion of hazards and preventive measures during well development activities.

6. References

Ecology and Environment, Inc., 1991, Geotechnical Log Book, copyright Ecology and Environment, Inc.

USATHAMA, March 1987, Geotechnical Requirements for Drilling, Monitoring Wells, Data Acquisition, and Reports.



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**OVERBURDEN MONITORING WELL/
PIEZOMETER INSTALLATION**

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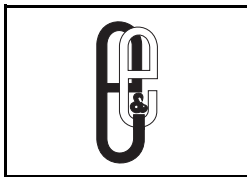
STANDARD OPERATING PROCEDURE

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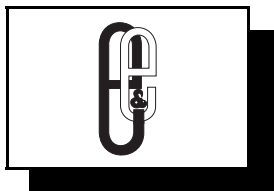
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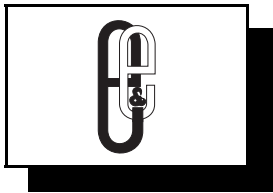
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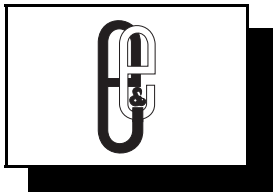
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1. Introduction

1.1 Scope

This document outlines the procedures to be followed by the subcontract drilling company for the drilling and installation of overburden monitoring wells and piezometers. It has been developed to supplement standard operating procedures currently used by Ecology and Environment, Inc., (E & E).

1.2 Objectives

Overburden monitoring wells and piezometers are installed to allow for the collection of groundwater samples for chemical and physical analysis, to aid in the definition and tracking of contaminants in the groundwater, and to provide access to groundwater for elevation measurement aquifer testing.

2. Selection Criteria for Wells and Piezometers

2.1 Data Objectives

The design and construction of an overburden monitoring well, or piezometer, must take into account the client's data objectives. Construction techniques and materials must not alter the chemical or physical properties of the groundwater being sampled, and must provide samples that are truly representative of the aquifers sampled. An understanding of the site geology and chemical properties of suspected contaminants is a prerequisite for the proper selection of construction techniques and materials.

2.2 Material Specifications

The type of material used in overburden monitoring wells and piezometers can have a detrimental effect on the quality of the sample to be collected. The materials of choice should retain their structural integrity for the duration of the monitoring program under actual subsurface conditions. The materials should neither adsorb nor leach chemical constituents that would bias the collection of representative samples.

The most commonly used materials for screen and riser sections include: thermoplastics such as polyvinyl chloride (PVC) and acrylonitrile butadiene styrene (ABS); fluoropolymers such

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as polytetrafluoroethylene/tetrafluoroethylene (PTFE/TFE or Teflon) and fluorinated ethylene propylene (FEP or Neflon); metallic such as carbon steel, galvanized steel and stainless steel; and fiberglass-reinforced such as fiberglass-reinforced epoxy (FRE) and fiberglass-reinforced plastic (FRP). Each material has advantages and disadvantages relating to factors such as cost, long-term structural integrity, chemical inertness under site conditions (including exposure to acids, caustic substances, and various organic solvents), and sorptive properties. The majority of overburden monitoring wells and piezometers are constructed from 2-inch inside diameter (I.D.) pipe; however, 4- and 6-inch I.D. wells are also common. The sections of pipe should be joined by flush threaded couplings to form watertight unions that retain 100% of the strength of the pipe. The bottom of the screen should be fitted with a threaded plug. No solvents or cements should be used in the construction of the wells.

2.2.1 Thermoplastics

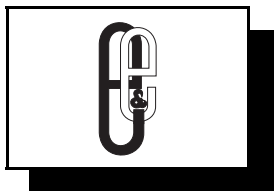
Thermoplastics are lightweight, relatively inexpensive, and generally have good-to-excellent chemical resistance (fluoropolymers have the best chemical resistance, except for fluorinated solvents; PVC has poor resistance to high concentrations of aromatic hydrocarbons, esters, and ketones). Thermoplastics are generally weaker, less rigid, and more temperature-sensitive than metallic materials (ABS has low strength and less heat resistance compared to PVC). PVC may also absorb some constituents from groundwater, and might react with and leach some constituents into groundwater.

2.2.2 Fluoropolymers

Fluoropolymers are expensive when compared to PVC and may not be readily available. PTFE/TFE has a lower tensile strength than PVC and the screen slot opening might decrease in size over time. The anti-stick properties of fluoropolymer materials make it difficult to achieve an annular seal with cement grout, creating the potential for the alteration of groundwater chemistry by percolating surface water, or groundwater movement between water-producing zones.

2.2.3 Metallic

The advantages of metallic well construction materials are their high strength and availability. Stainless steel has the least adsorption of halogenated and aromatic hydrocarbons, and resists degradation by corrosion and oxidation. Stainless steel is heavier and more expensive than plastics, although the potential exists for stainless steel to corrode and leach some chromium into highly acidic water, and in addition, might act as a catalyst in some organic reactions. Carbon steel rusts easily under saturated conditions, providing highly sorptive surfaces for many metals, and deteriorates in corrosive environments.



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2.2.4 Fiberglass-Reinforced

Fiberglass-reinforced plastics approach the strength of stainless steel, are lightweight and relatively inert in most monitoring well environments. Unfortunately, fiberglass-reinforced plastics are not readily available, and little data is available on its performance in the field.

2.2.5 Center Guides

If casing or screen assemblies exceeding 40 feet in length are installed in holes having an annulus 2 inches or larger than the outside diameter of the casing, center guides (centralizers) can be used to ensure that the screen and riser are centered in the borehole. If used, the guides should be placed at the bottom of the string and at 20-foot intervals.

2.2.6 Well Screen Characteristics

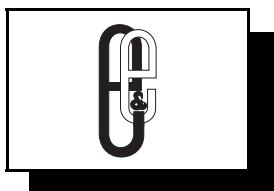
All well screens should allow groundwater to enter the monitoring well or piezometer for sampling. Well screens of appropriate length and slot size are attached to solid riser sections and placed at the desired sampling depth in the aquifer. The slot size is selected to maximize open area for water to flow through, and minimize entry of fines into the well during pumping. The major types of well intake screens are factory-slotted, continuous-slot, bridge-slot, and shutter-type. Other types include field-slotted pipe, in which slots are manually cut, and wire-wound perforated pipe. The slot size most commonly used by E & E in overburden monitoring wells and piezometers measures 0.010 inches in width, but can be as large as 0.080 inches in width for recovery wells. It is recommended that factory-slotted screens be specified to insure the integrity of the well screen.

2.2.7 Filter Pack

The filter pack increases hydraulic conductivity around the well screen and inhibits fine particles from entering the well screen during groundwater sampling. The filter pack must be clean (to minimize loss of material during development), have well-rounded grains (to increase hydraulic conductivity, porosity, yield, and effectiveness of well development), have 90 to 95% quartz grains (to minimize changes to groundwater chemistry and to eliminate loss of volume by dissolution of minerals), and have a uniform coefficient of 2.5 or less (to minimize separation during installation and lower head loss). E & E has found that a sandpack consisting of a No. 3 (00N or 3Q) quartz sand generally meets the formation requirements when used in conjunction with 0.010-inch well screens.

2.2.8 Well Seal

To prevent the vertical movement of surface water into the overburden monitoring well or piezometer, and to prevent cement grout from entering the filter pack, a bentonite seal is placed on top of the filter pack. The bentonite seal is normally two linear feet thick and can be used either as unhydrated pellets or chips with water added later, or pumped down through tremie



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pipe as a slurry. The bentonite should be tested for inorganic contaminants or should be certified by the manufacturer as meeting the ASTM D5092-90 specifications.

The annulus above the bentonite seal should be filled with a cement bentonite grout. The typical cement grout consists of Portland Type I or II cement and 3 to 6% bentonite powder.

3. Overburden Well Installation

3.1 Inspection and Cleaning of Drilling Equipment

Proper cleaning of the drill rig and down hole equipment upon arriving at the site and between drilling locations is necessary to minimize the potential introduction of contaminants into the groundwater. Care should be taken to steam clean the drill rig and all other equipment and well components before they are used. The drill rig should be checked repeatedly for oil and hydraulic fluid leaks. These precautions are essential to ensure that trace contaminants from the drilling process are not introduced to the monitoring well.

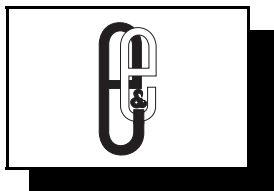
3.2 Installation Procedures

The monitoring well or piezometer will be installed in a borehole drilled and sampled as outlined in Standard Operating Procedures for Borehole Installation (GEO 4.7). Unless otherwise indicated, the monitoring well will be installed in such a manner as to allow a minimum of 2 feet of screen to extend above the static groundwater level. The screen and riser sections will be decontaminated as outlined in the work plan. (At a minimum, the screen and riser sections will be washed with a high-pressure washer/steam and allowed to air dry.) The plug will be installed in the bottom of the first screen section placed inside the hollow stem auger. The first section of screen will be lowered until 2 feet of screen extends above the top of the augers, with a well clamp used to hold the screen in place. Additional screen and riser sections will be added until the well has reached its designed depth. The top of the casing will extend 2 to 3 feet above ground elevation, except when the well is flush-mounted.

The augers will be raised in 2-foot increments and the filter pack installed in the annulus. This process will continue until the filter pack extends at least 2 linear feet above the screened interval. The sand may bridge in the annulus if the sand is poured too quickly, requiring a water flush to clear the bridge.

After the filter pack has been installed and measurements have been taken to ensure the proper location of the filter pack, at least 2 linear feet of bentonite pellets or bentonite slurry will be placed on top of the filter pack. If the bentonite seal is above the water table, then water must be added during the placement of the seal to hydrate the bentonite at a rate of approximately one gallon of water for every two pounds of bentonite.

After the bentonite seal is in place, has been allowed to set, and measurements have been taken to ensure its proper location, a cement and bentonite grout will be tremied in place from the top of the seal to the land surface. This will be accomplished in such a manner that a tight,



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continuous grout seal is present through the entire interval. Cement and bentonite mixtures will consist of potable water, bentonite powder, and Type I portland cement with 94 pounds of cement and 5 pounds of bentonite per 6.5 gallons of water. The grout will be allowed to set at least 24 hours before the well is developed.

3.3 Well Security

If the well is to be completed using aboveground casing, the riser will extend 2 to 3 feet above land surface. A vented cap will be installed in the top of the riser. The riser will be covered by a lockable steel casing that is centered around the riser. The steel casing should be fitted with a locking cap and be of sufficient diameter to allow easy access to the well riser. The steel casing will be seated in a 2-foot by 2-foot by 4-inch concrete surface pad. In order to minimize the effects of frost action, the concrete pads will be constructed with galvanized steel-reinforcing fibers which will impart a greater durability to the well pad. The pad will be sloped away from the steel casing. Drain hole(s) will be drilled in the steel casing to facilitate drainage.

If the above-grade well is in a location accessible to vehicular traffic, three 4-inch diameter by 5-foot long cement filled steel guard posts will be installed radially around the well. The guard posts will be recessed approximately two feet into the ground and set in concrete. The post will be placed around, but not in, the concrete pad placed at the well base.

4. Overburden Well Development

4.1 Rationale

During the drilling process, fine-grained materials are forced into the open borehole, forming a mudcake that reduces the hydraulic conductivity of the materials opposite the screened portion of the well. Proper development of the well or piezometer removes fines from the filter pack, which improves the hydraulic performance and eliminates or reduces the amount of sediment in water samples. Proper development also rectifies damage done during drilling to the borehole walls and adjacent formation.

4.2 Methods

Following well completion and set-up of grout, the well will be developed to remove the residuals from the annular wall spaces and to re-establish the normal hydraulic properties of the water-bearing zone. Each overburden well and piezometer will be developed by bottom-filling bailer, surging, or pumping until the minimum three well volumes of water as recommended by the American Society for Testing and Materials (ASTM) has been removed. Routine field tests will be conducted on the development water to determine turbidity, specific conductivity, pH, and temperature. Development will be considered completed when these field test parameters



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have stabilized and no further improvement in the turbidity of the development water is observed.

5. Disposal of Drill Cuttings and Fluids

5.1 Containerization of Drill Cuttings and Fluids

Drill cuttings, drill fluids, and development water must be handled as outlined in the work plan for the site. In most instances, the drill cuttings are classified as hazardous waste under the Resource Conservation and Recovery Act (RCRA) and must be placed in U.S. Department of Transportation (DOT) approved 55-gallon steel drums pending analysis. Drums containing drill cuttings must be properly labeled and marked with the source of the drill cuttings (i.e., "MW-2") prior to being staged. Drill fluids and development water must also be placed in DOT-approved 55-gallon steel drums pending analysis. The drums of drill fluids and development water must be properly labeled and marked with the source of the fluids and the date that the material was generated prior to being staged.

5.2 Disposal of Drill Cuttings and Fluids

Upon receipt of the analytical results, the drill cuttings, drill fluids, and development water can be properly classified. It is the responsibility of the property owner and/or client to arrange for the disposal of the drill cuttings and fluids at an approved facility.

6. Well Completion Reports

6.1 Well Construction Summary Sheets

At the completion of the overburden monitoring well or piezometer, a well construction summary sheet will be completed by the driller. An example of the well construction summary sheet used by E & E is attached as Figure 1. The summary sheet summarizes details of the well construction (i.e., screened interval, water level, filter pack height, bentonite placement, etc.).

6.2 Well Completion Cost Sheet

At the completion of the fieldwork, a cost sheet outlining the costs associated with the installation of the overburden monitoring well or piezometer will be completed. An example of a cost sheet is attached as Figure 2.

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WELL INSTRUMENTATION LOG

Project Name: _____ Project Number: _____

Client: _____ Location: _____

Start Date: _____ Completion Date: _____

Drilling Method: _____ Driller: _____

Development Method: _____ Development Duration: _____

Water Level in Completed Borehole (ft/m): _____

Split Spoon Size: _____

Depth _____

Shelby Tube Size: _____

Depths: _____

SCREENED WELL		OPEN-HOLE WELL	
Stick-up _____ ft		Stick-up _____ ft	
Inner Casing Material _____		Inner Casing Material _____	
Inner Casing Inside Diameter _____ Inches		Inner Casing Inside Diameter _____ Inches	
Top of Grout _____ ft		Top of Grout _____ ft	
Borehole _____ Inches Diameter _____ ft		Bottom of Outer Casing _____ ft	
Top of Seal at _____ ft		Borehole Diameter _____ ft	
Bottom of Seal at _____ ft		Bedrock _____ ft	
Top of Screen at _____ ft		Bottom of Rock Socket/ Grout/Casing _____ ft	
Pack Type/Size: <input type="checkbox"/> Sand _____ <input type="checkbox"/> Gravel _____ <input type="checkbox"/> Natural _____		Corehole Diameter _____	
Bottom of Screen at _____ ft		Bottom of Corehole _____ ft	
	Quantity of Material Used: Bentonite Pellets _____ Cement _____ Cement/Bentonite _____ Grout _____ Top of Sand Pack _____ Screen Slot Size _____ Screen Type <input type="checkbox"/> PVC _____ <input type="checkbox"/> Stainless Steel _____ Bottom of Hole at _____ ft Bottom of Sandpack at _____		

Figure 1 Well Construction Summary Sheet

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**COST SHEET FOR DRILLING, SAMPLING, AND INSTALLATION
OF TWO-INCH I.D. MONITORING WELLS**

Client: _____

Job Number: _____ Prepared by: _____ Date: _____

Bid Item	Description	Unit Price	Estimated Quantities	Totals
1	Mobilization and Demobilization	\$4.00/Mile or \$400.00	_____ Miles	_____
2	Soil Boring (4.25" HSA)	\$12.00/LF	_____ LF	_____
2a	Soil Boring (6.25" HSA)	\$15.00/LF	_____ LF	_____
3	Well Installation	\$13.00/LF	_____ LF	_____
4	Split Spoon Samples Every 5 Feet	\$20.00/ Sample	_____ Samples	_____
5	Split Spoon Samples Continuous	\$10.00/Foot	_____ Feet	_____
6	Rock Coring/Concrete Coring	\$30.00/LF	_____ LF	_____
7	Core Boxes	\$40.00 ea	_____	_____
8	2-Inch I.D. PVC Riser	\$3.75/LF	_____ LF	_____
9	2-Inch I.D. PVC Screen (0.010")	\$6.75/LF	_____ LF	_____
10	8-Inch I.D. Carbon Steel Casing	\$24.00/LF	_____ LF	_____
10a	4-Inch I.D. Carbon Steel Casing	\$19.00/LF	_____ LF	_____
11	Plugs and Caps, PVC	\$4.44 ea	_____	_____
11a	Plugs and Caps, SS	\$30.00 ea	_____	_____

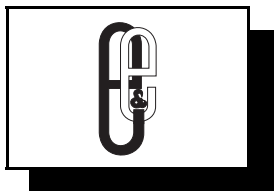
Figure 2 Well Completion Cost Estimate Sheet



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Bid Item	Description	Unit Price	Estimated Quantities	Totals
12	Sand	\$6.00/LF	_____ LF	_____
13	Bentonite (Pellets)	\$15.00/LF	_____ LF	_____
14	Cement (Boreholes)	\$5.00/LF	_____ LF	_____
15	Cement/Bentonite (Wells) (10%) Grout	\$6.00/LF	_____ LF	_____
16	Shelby Tube, 3" by 30"	\$100.00 ea	_____ Wells	_____
17	Well Development (1.5 Hours/Well)	\$150.00	_____ HR	_____
18	Decontamination Time	\$100.00/HR	_____ Wells	_____
19	Furnish and Installed Flush Well Protector	\$500.00/Well	_____ Pads	_____
20	Reaming to 5 7/8 Inches	\$26.00/LF	_____ HR	_____
21	Bentonite Seal Between Auger and Bedrock	\$36.00/LF	_____ Wells	_____
22	Decon Pad Construction	\$100.00/Pad	_____ Wells	_____
23	Standby Time	\$85.00/HR	_____ Wells	_____
24	Well Abandonment (2.5 Hours/Well)	\$250.00 ea	_____ Wells	_____
This cost sheet represents a summary of the estimated drilling costs associated with the installation of monitoring wells and/or soil borings at the location noted above. Any questions should be brought to the attention of E & E as soon as possible.			Subtotal	_____
			Discount	_____
			Total	_____

Figure 2 Well Completion Cost Estimate Sheet



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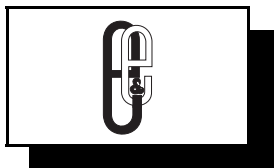
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1. Introduction

Liquid and solid environmental samples are routinely collected by E & E during field surveys, site investigations, and other site visits for laboratory analysis. Unless the samples have anesthetic, noxious, or other properties that could inhibit the ability of a flight crew member to perform his or her duty or are known to meet the established U.S. Department of Transportation criteria for hazardous material (i.e., explosive, corrosive, flammable, poisonous), they are not regulated as hazardous materials.

This Standard Operating Procedure (SOP) describes the packaging procedures to be used by E & E's staff to ensure the safe arrival of the samples at the laboratory for analyses. These procedures have been developed to reduce the risk of damage to the samples (i.e., breakage of the sample containers), promote the maintenance of sample temperature within the cooler, and prevent spillage of the sampled material should a container be broken.

In the event the sample material meets the established criteria of a DOT hazardous material, the reader is referred to E & E's Hazardous Materials/Dangerous Goods Shipping Guidance Manual (see H&S 5.5).

2. Scope

This SOP describes procedures for the packaging of environmental samples in:

- Coolers;
- Steel, aluminum and plastic drums; and
- 4GV fiberboard boxes.

The Hazardous Materials/Dangerous Goods Shipping Guidance Manual will complete the information needed for shipping samples by providing guidance on:

- Hazard determination for samples which meet the USDOT definition of a hazardous material;
- Shipping profiles for "standard" shipments;
- Shipping procedures for "non-standard" shipments;
- Marking of packages containing hazardous materials;



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- Labeling of packages containing hazardous materials; and
- Preparation of shipping papers for hazardous materials shipment.

3. Sample Packaging Procedures

3.1 General

It is E & E's intent to package samples so securely that there is no chance of leakage during shipment. This is to prevent the loss of samples and the expenditure of funds for emergency responses to spills and the efforts necessary to re-obtain the sample.

Over the years, E & E has developed several "standard" package configurations for the shipping of environmental samples. These standard package configurations are described below.

Liquid samples are particularly vulnerable. Because transporters (carriers) do not know the difference between a package leaking distilled water and a package leaking a hazardous chemical, they will react to a spill in an emergency fashion, potentially causing enormous expense to E & E for the cleanup of the sample material. Therefore, liquids are to be packed in multiple layers of plastic bags and absorbent/cushioning material to preclude any possibility of leaks from a package. This section defines the standard packaging configurations for environmental samples.

3.2 Liquid Environmental Sample Packaging Procedures

Liquid environmental samples should be collected and preserved as outlined in the Standard Operating Procedures (SOP) for Surface Water Sampling (ENV 3.12), and Groundwater Well Sampling (ENV 3.7). ***Preserved water samples are not considered to meet the HM/DG definitions of Class 8 (Corrosive) and are therefore considered to be nonhazardous samples.*** Liquid environmental samples may be shipped using an 80-quart cooler or an outer package consisting of either a steel or aluminum drum. Because the steel and aluminum drums provide little insulating capability, they should not be used for samples that require icing.

Packaging Liquid Environmental Samples Using the 80-Quart Cooler

- Label and seal all water sample bottles according to appropriate sampling SOPs;
- Secure the bottle caps using fiberglass tape; and
- Place each amber, poly, and volatile organic analysis (VOA) bottle in a sealable plastic bag. Mark the temperature blank VOA bag for identification.

If a foam block insert is used:

- Line the cooler with two plastic bags;



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- Place a foam insert (with holes cut to receive the sample bottles) inside the plastic bag;
- Place the bottles in the holes in the foam block;
- Fill void spaces with bagged ice to the top of the cooler;
- Fold over the plastic bags lining the cooler and secure shut with tape;
- Place Chain-of-Custody (C-O-C) form in a sealable bag and tape it to the inside of the cooler lid; and
- Secure the cooler with strapping tape and custody seal. Cover the custody seals with clear tape.

If vermiculite is used:

- Place 1 inch of inert absorbent material (vermiculite) in the bottom of the cooler;
- Line the cooler with two plastic bags;
- Place each sample bottle inside the inner bag;
- Fill the void spaces around the bottles with vermiculite to about half the height of the large bottles;
- Fill the remainder of the void spaces with bagged ice to within 4 inches of the top of the cooler, making sure the VOAs are in direct contact with a bag of ice;
- Fold over the plastic bags lining the cooler and secure shut with tape;
- Fill the remaining space in the cooler with vermiculite to the top of the cooler;
- Place C-O-C form in a sealable bag and tape it to the inside of the cooler lid; and
- Secure the cooler with strapping tape and custody seal. Cover the custody seals with clear tape.

Alternate Packaging Using 1A2/1B2 Drum

- Place 3 inches of inert absorbent material (vermiculite) in the bottom of the drum;
- Line the drum with two plastic bags;



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- Place each sample bottle inside the inner bag;
- Fill the void spaces around the bottles with vermiculite to the height of the larger bottles;
- Fold over the plastic bags lining the drum and secure shut with tape;
- Fill the remaining space in the drum with vermiculite to the top of the drum;
- Place C-O-C form in a sealable bag and tape it to the inside of the drum lid; and
- Secure the drum with closing ring and apply custody seals. Cover the custody seals with clear tape.

3.3 Soil/Sediment Environmental Sample Packaging Procedures

Soil/sediment environmental samples should be collected as outlined in the SOP for Soil Sampling (ENV 3.13), and SOP for Sediment Sampling (ENV 3.8). Soil/sediment environmental samples may be shipped using an 80-quart cooler, a 4GV fiberboard combination package, or an outer package consisting of either a steel or aluminum drum. Because the steel and aluminum drums provide little insulating capability, they should not be used for samples that require icing.

Packaging Soil/Sediment Environmental Samples

- Label and seal each sample container according to SOPs;
- Secure the bottle caps using fiberglass tape;
- Place each sample bottle inside a sealable plastic bag and place it in its original shipping box or in individual fiberboard boxes. Mark the temperature blank bag for identification; and
- Secure the original shipping box with strapping tape, place shipping box in a plastic bag, and secure the plastic bag with tape.

If an 80-quart cooler is used:

- Place bubble pack or similar material on the bottom and sides of an 80-quart cooler;
- Place the bagged shipping boxes in the cooler with a layer of bubble pack between each box;



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- Fill the void spaces with "blue ice" or ice in baggies to the top of the cooler;
- Place C-O-C form in a sealable baggie and tape it to the inside of the cooler lid; and
- Secure the cooler with strapping tape and custody seal. Cover the seals with clear tape.

If a 1A2/1B2 drum is used:

- Place 3 inches of inert absorbent material (vermiculite) in the bottom of the drum;
- Line the drum with two plastic garbage bags;
- Place the boxes inside the inner bag;
- Fill the space around the samples with vermiculite;
- Fold over the plastic bags lining the drum and secure shut with tape;
- Fill the remaining space around the bags with vermiculite to the top of the drum;
- Place C-O-C form in a sealable bag and tape it to the inside of the drum lid; and
- Secure the drum with the closing ring and apply custody seals. Cover the custody seals with clear tape.

Note: If a small number of samples are being shipped, it may be more practical to package them using the vermiculite or foam block configurations used for shipping liquid samples.

4. Shipping Procedures

Environmental samples are to be shipped as nonhazardous cargo. Unless the samples have anesthetic, noxious, or other properties that could inhibit the ability of a flight crew member to perform his or her duty or are known to meet the established U.S. Department of Transportation criteria for a hazardous material (i.e., explosive, corrosive, flammable, poisonous), they are not regulated as hazardous materials. When preparing the containers (i.e., cooler, drum, or box) for shipment, E & E staff **must** remove all labels from the outside container. Labels indicating that the contents may be hazardous are misleading and are not appropriate. Markings indicating ownership of the container, destination, and chain of custody labels are acceptable and can be attached as required.



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When completing the paperwork for shipment, the standard nonhazardous forms must be used. Do not use the hazardous materials/dangerous goods airbills, either in total or in part; these forms are coded and their use will invite unnecessary questions. This will only serve to confuse Airborne or Federal Express' terminal personnel and will cause much frustration and the delay of sample shipment.

Environmental sample packages can be shipped overnight by both Airborne and Federal Express. When choosing between the two, cost should be considered. It is normally much cheaper to ship Airborne. For work conducted and paid for by E & E, it is E & E's policy that you must first attempt to ship by Airborne before considering Federal Express. In addition, Airborne tends to have remote locations open later in the evenings than Federal Express, which may be helpful when trying to complete a full day's sampling effort and still make the flights on time. Although both companies offer pickup of samples at the site, it is advisable to call ahead and ensure that this service is offered beforehand. In almost all cases, both companies will deliver to the laboratory of your choice on Saturdays. When planning for sampling activities, check with the companies in advance to verify pick-up and delivery schedules.



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Sampling Equipment Decontamination

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STANDARD OPERATING PROCEDURE

SAMPLING EQUIPMENT DECONTAMINATION

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1. Scope and Application

The purpose of this procedure is to provide a description of methods for preventing or reducing cross-contamination and general guidelines for designing and selecting decontamination procedures for use at potential hazardous waste sites. The decontamination procedures chosen will prevent introduction and cross-contamination of suspected contaminants in environmental samples, and will protect the health and safety of site personnel.

2. Method Summary

Removing or neutralizing contaminants that have accumulated on personnel and equipment ensures protection of personnel from permeating substances, reduces/eliminates transfer of contaminants to clean areas, prevents the mixing of incompatible substances, and minimizes the likelihood of sample contamination.

Cross-contamination can be removed by physical decontamination procedures. The abrasive and non-abrasive methods include the use of brushes, high pressure water, air and wet blasting, and high pressure Freon cleaning. These methods should be followed by a wash/rinse process using appropriate cleaning solutions. A general protocol for cleaning with solutions is as follows:

1. Physical removal.
2. Non-phosphate detergent plus tap water.
3. Tap water.
4. 10% nitric acid.
5. Distilled/deionized water rinse.
6. Solvent rinse.
7. Total air dry.
8. Triple rinse with distilled/deionized water.

This procedure can be expanded to include additional or alternate solvent rinses that will remove specified target compounds if required by site-specific work plans (WP) or as directed by a particular client.



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3. Interferences

The use of distilled/deionized water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been verified by laboratory analysis to be analyte-free distilled/deionized water. Distilled water available from local grocery stores and pharmacies is generally not acceptable for final decontamination rinses. Contaminant-free deionized water is available from commercial vendors and may be shipped directly to the site or your hotel.

The use of an untreated potable water supply is not an acceptable substitute for tap water. Tap water may be used from any municipal water treatment system.

4. Equipment/Apparatus

The following are standard materials and equipment used as a part of the decontamination process:

- Appropriate protective clothing;
- Air purifying respirator (APR);
- Field log book;
- Non-phosphate detergent;
- Selected high purity, contaminant-free solvents;
- Long-handled brushes;
- Drop cloths (plastic sheeting);
- Trash containers;
- Paper towels;
- Galvanized tubs or equivalent (e.g., baby pools);
- Tap water;
- Contaminant-free distilled/deionized water;
- Metal/plastic container for storage and disposal of contaminated wash solutions;
- Pressurized sprayers, H₂O;
- Pressurized sprayers, solvents;
- Trash bags;
- Aluminum foil;
- Sample containers;
- Safety glasses or splash shield; and
- Emergency eyewash bottle.



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5. Reagents

There are no reagents used in this procedure aside from decontamination solutions used for the equipment. The type of decontamination solution to be used shall depend upon the type and degree of contamination present and as specified in the project/site-specific Quality Assurance Project Plan (QAPP).

In general, the following solvents are utilized for decontamination purposes:

- 10% nitric acid wash (reagent grade nitric acid diluted with deionized/distilled water – 1 part acid to 10 parts water)^a;
- Acetone (pesticide grade)^b ;
- Hexane (pesticide grade)^b;
- Methanol; and
- Methylene chloride^b.

^aOnly if sample is to be analyzed for trace metals.

^bOnly if sample is to be analyzed for organics requiring specific or specialized decontamination procedures. These solvents must be kept away from samples in order to avoid contamination by decon solvents.

6. Procedures

Decontamination is the process of removing or neutralizing contaminants that have accumulated on both personnel and equipment. Specific procedures in each case are designed accordingly and may be identified in either the Health and Safety Plan (HSP), WP, QAPP, or all three.

As part of the HSP, a personnel decontamination plan should be developed and set up before any personnel or equipment enters the areas of potential contamination. Decontamination procedures for equipment will be specified in the WP and the associated QAPP. These plans should include:

- Number and layout of decontamination stations;
- Decontamination equipment needed (see Section 4);
- Appropriate decontamination methods;
- Procedures to prevent contamination of clean areas;
- Methods and procedures to minimize worker contact with contaminants during removal of protective clothing;



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- Methods and procedures to prevent cross-contamination of samples and maintain sample integrity and sample custody; and
- Methods for disposal of contaminated clothing, equipment, and solutions.

Revisions to these plans may be necessary for health and safety when the types of protective clothing, site conditions, or on-site hazards are reassessed based on new information.

Prevention of Contamination

Several procedures can be established to minimize contact with waste and the potential for contamination. For example:

- Employing work practices that minimize contact with hazardous substances (e.g., avoid areas of obvious contamination, avoid touching potentially hazardous substances);
- Use of remote sampling, handling, and container-opening techniques;
- Covering monitoring and sampling equipment with plastic or other protective material;
- Use of disposable outer garments and disposable sampling equipment with proper containment of these disposable items;
- Use of disposable towels to clean the outer surfaces of sample bottles before and after sample collection; and
- Encasing the source of contaminants with plastic sheeting or overpacks.

Proper procedures for dressing prior to entrance into contaminated areas will minimize the potential for contaminants to bypass the protective clothing. Generally, all fasteners (zippers, buttons, snaps, etc.) should be used, gloves and boots tucked under or over sleeves and pant legs, and all junctures taped (see the Health and Safety Plan for these procedures).

Decontamination Methods

All personnel, samples, and equipment leaving the contaminated area of a site must be decontaminated to remove any chemicals or infectious organisms that may have adhered to them. Various decontamination methods will either physically remove, inactivate by chemical detoxification/disinfection/sterilization, or remove contaminants by both physical and chemical means.

In many cases, gross contamination can be removed by physical means. The physical decontamination techniques can be grouped into two categories: abrasive methods and non-abrasive methods.



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6.1 Abrasive Cleaning Methods

Abrasive cleaning methods work by rubbing and wearing away the top layer of the surface containing the contaminant. The following reviews the available abrasive methods.

Mechanical

Mechanical methods include using brushes with metal, nylon, or natural bristles. The amount and type of contaminants removed will vary with the hardness of bristles, length of time brushing, and degree of brush contact. Material may also be removed by using appropriate tools to scrape, pry, or otherwise remove adhered materials.

Air Blasting

Air blasting equipment uses compressed air to force abrasive material through a nozzle at high velocities. The distance between nozzle and surface cleaned, air pressure, and time of air blasting dictate cleaning efficiency. The method's disadvantages are its inability to control the exact amount of material removed and its large amount of waste generated.

Wet Blasting

Wet blast cleaning involves the use of a suspended fine abrasive. The abrasive/water mixture is delivered by compressed air to the contaminated area. By using very fine abrasives, the amount of materials removed can be carefully controlled.

6.2 Non-abrasive Cleaning Methods

Non-abrasive cleaning methods work by either dissolution or by forcing the contaminant off a surface with pressure. In general, less of the equipment surface is removed using non-abrasive methods.

High-Pressure Water

This method consists of a high-pressure pump, an operator controlled directional nozzle, and high-pressure hose. Operating pressure usually ranges from 340 to 680 psi, which relates to flow rates of 20 to 140 lpm.

Steam Cleaning

This method uses water delivered at high pressure and high temperature in order to remove accumulated solids and/or oils.

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Ultra-High-Pressure Water

This system produces a water jet from 1,000 to 4,000 atm. This ultra-high-pressure spray can remove tightly-adhered surface films. The water velocity ranges from 500 m/sec. (1,000 atm) to 900 m/sec. (4,000 atm). Additives can be used to enhance the cleaning action, if approved by the QAPP for the project.

High-Pressure Freon Cleaning

Freon cleaning is a very effective method for cleaning cloth, rubber, plastic, and external/internal metal surfaces. Freon 113 (trichlorotrifluoroethane) is dense, chemically stable, relatively non-toxic, and leaves no residue. The vapor is easily removed from the air by activated charcoal. A high pressure (1,000 atm) jet of liquid Freon 113 is directed onto the surface to be cleaned. The Freon can be collected in a sump, filtered, and reused.

Physical removal of gross contamination should be followed by a wash/rinse process using cleaning solutions. One or more of the following methods utilize cleaning solutions.

Dissolving

Removal of surface contaminants can be accomplished by chemically dissolving them, although the solvent must be compatible with the equipment and protective clothing. Organic solvents include alcohols, ethers, ketones, aromatics, straight-chain alkanes, and common petroleum products. Halogenated solvents are generally incompatible with protective clothing and are toxic. Table 1 provides a general guide to the solubility of contaminant categories in four types of solvents.

Surfactants

Surfactants reduce adhesion forces between contaminants and the surface being cleaned and prevents reposition of the contaminants. Non-phosphate detergents dissolved in tap water is an acceptable surfactant solution.

Rinsing

Contaminants are removed and rinsing through dilution, physical attraction, and solubilization.

Disinfection/Sterilization

Disinfectants are a practical means of inactivating infectious agents. Unfortunately, standard sterilization methods are impractical for large equipment and personal protective clothing.

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6.3 Field Sampling Equipment Cleaning Procedures

The following steps for equipment cleaning should be followed for general field sampling activities.

1. Physical removal (abrasive or non-abrasive methods).
2. Scrub with non-phosphate detergent plus tap water.
3. Tap water rinse.
4. 10% nitric acid (required during sampling for inorganics only).
5. Distilled/deionized water rinse.
6. Solvent rinse (required during sampling for organics only).
7. Total air dry (required during sampling for organics only).
8. Triple rinse with distilled/deionized water.

Table 1 lists solvent rinses which may be required for elimination of particular chemicals. After each solvent rinse, the equipment should be air-dried and triple-rinsed with distilled/deionized water.

Table 1	
DECONTAMINATION SOLVENTS	
Solvent	Soluble Contaminants
Water	Low-chain compounds Salts Some organic acids and other polar compounds
Dilute Bases For example: – detergent – soap	Acidic compounds Phenol Thiols Some nitro and sulfonic compounds
Organic Solvents: For example: – alcohols (methanol) – ethers – ketones – aromatics – straight-chain alkanes (e.g., hexane) – common petroleum products (e.g., fuel oil, kerosene)	Nonpolar compounds (e.g., some organic compounds)
WARNING: Some organic solvents can permeate and/or degrade the protective clothing.	

Solvent rinses are not necessarily required when organics are not a contaminant of concern. Similarly, an acid rinse is not necessarily required if analysis does not include inorganics.

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NOTE: Reference the appropriate analytical procedure for specific decontamination solutions required for adequate removal of the contaminants of concern.

Sampling equipment that requires the use of plastic or teflon tubing should be disassembled, cleaned, and the tubing replaced with clean tubing, if necessary, before commencement of sampling or between sampling locations.

7. Quality Assurance/Quality Control

QA/QC samples are intended to provide information concerning possible cross-contamination during collection, handling, preparation, and packing of samples from field locations for subsequent review and interpretation. A field blank (rinsate blank) provides an additional check on possible sources of contamination from ambient air and from sampling instruments used to collect and transfer samples into sample containers.

A field blank (rinsate blank) consists of a sample of analyte-free water passed through/over a precleaned/decontaminated sampling device and placed in a clean area to attempt to simulate a worst-case condition regarding ambient air contributions to sample contamination.

Field blanks should be collected at a rate of one per day per sample matrix even if samples are not shipped that day. The field blanks should return to the lab with the trip blanks originally sent to the field and be packed with their associated matrix.

The field blank places a mechanism of control on equipment decontamination, sample handling, storage, and shipment procedures. It is also indicative of ambient conditions and/or equipment conditions that may affect the quality of the samples.

Holding times for field blanks analyzed by CLP methods begin when the blank is received in the laboratory (as documented on the chain of parameters and associated analytical methods).

Holding times for samples and blanks analyzed by SW-846 or the 600 and 500 series begins at the time of sample collection.

8. Health and Safety

Decontamination can pose hazards under certain circumstances even though performed to protect health and safety. Hazardous substances may be incompatible with decontamination methods (i.e., the method may react with contaminants to produce heat, explosion, or toxic products). Decontamination methods may be incompatible with clothing or equipment (e.g., some solvents can permeate and/or degrade protective clothing). Also, a direct health hazard to workers can be posed from chemical decontamination solutions that may be hazardous if inhaled or may be flammable.



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The decontamination solutions must be determined to be compatible before use. Any method that permeates, degrades, or damages personal protective equipment should not be used. If decontamination methods do pose a direct health hazard, measures should be taken to protect personnel or modified to eliminate the hazard.

All site-specific safety procedures should be followed for the cleaning operation. At a minimum, the following precautions should be taken:

1. Safety glasses with splash shields or goggles, neoprene gloves, and laboratory apron should be worn.
2. All solvent rinsing operations should be conducted under a fume hood or in open air.
3. No eating, smoking, drinking, chewing, or any hand-to-mouth contact is permitted.

9. References

Field Sampling Procedures Manual, New Jersey Department of Environmental Protection, 1988.

A Compendium of Superfund Field Operations Methods, EPA 540/p-87/001.

Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual, USEPA Region IV, April 1, 1986.

Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, NIOSH/OSHA/USCG/EPA, October 1985.



TITLE: SEDIMENT SAMPLING

CATEGORY: ENV 3.8

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STANDARD OPERATING PROCEDURE

SEDIMENT SAMPLING

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1. Introduction

This Standard Operating Procedure (SOP) describes the procedures for the collection of representative sediment samples. Analysis of sediment samples may determine whether concentrations of specific pollutants exceed established threshold action levels, and whether the concentrations of pollutants present a risk to public health, welfare, or the environment.

2. Scope

Included in this discussion are procedures for obtaining representative samples, quality assurance measures, proper documentation of sampling activities, and recommendations for personnel safety.

3. Method Summary

Sediment samples may be recovered using a variety of methods and equipment. These are dependent on 1) the depth of the water in which the samples will be collected; 2) the sediment's characteristics; 3) the volume of sediment required; and 4) the type of sample required (disturbed or undisturbed). Ultimately, the type of sampling device used should be consistent with the objective of the study.

Near-surface sediment samples may be collected using a scoop or spoon (if near shore or in shallow water), or sediment dredge or grab sampler (if in deeper water). To obtain other than surficial sediment samples, core samplers or split-spoon samplers are required.

All sampling devices should be cleaned using pesticide-grade acetone (assuming that acetone is not a target compound) or methanol, rinsed with distilled water, wrapped in aluminum foil, and custody sealed for identification. The sampling equipment should remain in this wrapping until needed. Each sampler should be used for one sample only. However, dedicated samplers may be impractical if there are a large number of sediment samples to be collected. In this case, samplers should be cleaned in the field using the decontamination procedures outlined in E & E's *Equipment Decontamination SOP*.



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4. Sample Preservation, Containers, Handling, and Storage

The chemical preservation of sediments is not generally recommended. Refrigeration is usually the best approach, supplemented by a minimal holding time. Sediment samples should be handled according to standard techniques and project-specific requirements as detailed in project work/sampling plans and quality assurance project plans.

5. Potential Problems

Potential problems with sediment sampling include cross-contamination of samples and improper sample collection. Cross-contamination problems may be eliminated or minimized through the use of dedicated sampling equipment and bottles. If this is not possible or practical, then proper decontamination of sampling equipment is necessary. Improper sample collection can involve using inadequate or inappropriate sampling devices, contaminated equipment, disturbance of the matrix resulting in compaction of the sample, and inadequate homogenization of the sample where required, resulting in variable, nonrepresentative results.

6. Equipment

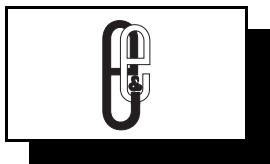
The following is a list of equipment and items typically used for sediment sampling:

- Sampling plan,
- Sample location map,
- Safety equipment, as specified in the health and safety plan,
- Compass,
- Survey equipment,
- Tape measure,
- Camera,



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- Four-ounce and eight-ounce glass jars with teflon liners,
- 40-ml glass vials with teflon-backed septum,
- Plastic bags for sample jars,
- Logbook,
- Labels,
- Waterproof ink pen,
- Chain-of-custody forms,
- Shipping cooler,
- Decontamination supplies and equipment, as described in the work plan,
- Canvas or plastic sheeting,
- Stainless-steel scoops,
- Stainless-steel spoons,
- Stainless-steel mixing bowls, or pans,
- Hand-driven split-spoon sampler,
- Shovel,
- Stainless-steel hand auger,
- Sediment dredge/grab sampler,
- Manual, gravity, or mechanical coring devices, and
- Teflon beaker attached to a telescoping pole.



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7. Reagents

Sediment sampling does not require the use of reagents except for decontamination of equipment. Refer to E & E's *Equipment Decontamination SOP* and the site-specific work plan for proper decontamination procedures and appropriate solvents.

8. Procedures

8.1 Office Preparation

- Prepare a sampling plan in accordance with contract requirements. Conduct a literature and information search and review available background information (e.g., topographic maps, soil survey maps, geological survey maps, other site reports, etc.) to determine the extent of the sampling effort, the sampling methods to be employed, and the type and amounts of equipment and supplies required.
- E & E corporate policy requires that a health and safety plan be prepared prior to commencing any sampling activity. The plan must be approved and signed by the corporate health and safety officer or his/her designee (e.g., the regional safety coordinator [RSC]).
- Obtain necessary sampling and monitoring equipment (see Section 6), and ensure that everything is in working order.
- Contact delivery service to confirm ability to ship all equipment and samples. Determine whether shipping restrictions exist.
- Prepare schedules and coordinate with staff, clients, property owners, and regulatory agencies, if appropriate.

8.2 Field Preparation

- Identify local suppliers of sampling expendables and overnight delivery services (e.g., Federal Express).
- Decontaminate or preclean all equipment before sediment sampling, as described in E & E's *Equipment Decontamination SOP*, or as deemed necessary.



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- Calibrate all health & safety monitoring equipment daily.
- A general site survey should be performed prior to site entry, in accordance with the health and safety plan. A site safety meeting identifying physical and chemical hazards should be conducted prior to sampling activities.
- Identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. All locations must be cleared of utilities by the property owner or utility companies prior to sediment sampling.

8.3 Sample Collection

Numerous techniques and sampling devices may be employed to collect representative sediment samples. A number of sampling-related factors can contribute to the loss of sample integrity, including washout of fine-grained sediments during retrieval; compaction due to sample wall friction; and sampling vessel- or person-induced disturbance of surficial layers. Choosing the most appropriate sediment sampler for a study will depend on the sediment's characteristics, the volume and efficiency required, and the objectives of the study.

Most samples will be grab samples, although occasionally, sediment taken from various locations may be combined into one composite sample to reduce the amount of analytical support required.

The following procedure is used to collect surface sediment samples from small, low-flowing streams or near the shore of a pond or lake:

1. The sampler should select the sampling location furthest downstream for the first sample and work upstream. This will reduce the potential for disturbed sediments from migrating down to unsampled locations. This technique will also reduce the chances of cross-contaminating subsequent samples by sampling first in areas of suspected low contamination and working to the suspected higher concentration areas.
2. Using a precleaned, stainless-steel scoop, spoon, or other appropriate device, remove the required volume of sediment from the desired surface interval (e.g., 0-inch to 6-inch), place the sample in the appropriate precleaned glass jar, decant excess liquid as necessary, and secure the teflon-lined lid to the jar. If the sample is to be a composite sample, or if the sample is to be homogenized, the sediment is first placed in a stainless-steel mixing bowl and is homogenized prior to placement in the glass sample container. Samples for volatile organic analysis are not homogenized. Samples are handled in accordance with project-specific requirements.

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3. Carefully and clearly identify the jar with the appropriate sample label, ensuring that all the categories or parameters listed in Section 10.1.1 have been addressed. Place a custody seal on the jar and lid, secure the seal in place with clear tape, and refrigerate the sample. The clear tape should also cover the jar's label.
4. Use the chain-of-custody form to document the types and number of sediment samples collected for shipment to a laboratory for analyses.
5. In the field logbook record the time and date of sample collection, as well as a description of the sample and any associated air monitoring measurements.
6. Decontaminate sampling equipment in accordance with E & E's *Equipment Decontamination SOP*.

The following procedure is used to collect subsurface sediment samples from small, low-flowing streams or near the shore of a pond or lake:

1. The sampler should select the sampling location farthest downstream for the first sample and work upstream. This will reduce the potential for disturbed sediments from migrating downstream to unsampled locations, and will also reduce the chances of cross-contaminating subsequent samples.
2. Using a precleaned split-spoon sampler or other hollow coring device, drive the sampler to the required depth with a smooth continuous motion. Remove the coring device by rotating and lifting it in a single smooth motion until the sampler is free from the sediment.
3. Before the sediment sample can be removed from the sampling device, the overlying water must be removed from the sampler by slowly pouring or siphoning it off near one side of the sampler. Care should be taken to ensure that the sediments are not disturbed, and that the fine-grained surficial sediment and organic matter are not lost while removing the overlying water.
4. Disassemble the split-spoon sampler by placing pipe wrenches on either end of the sampler. Remove both ends and open the split spoon with a precleaned stainless-steel spoon. Recover the sediment core from a core tube by pushing the sample out with a precleaned stainless-steel spoon.



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5. Collect the necessary sample by cutting the core with the handle of a precleaned stainless-steel spoon, placing the sample in the appropriate precleaned glass jar, and securing the teflon-lined lid to the jar. Samples are handled in accordance with project-specific requirements.
6. Carefully and clearly label the jar with the appropriate sample tag, ensuring that all of the categories or parameters listed in Section 10.1.1 have been addressed. Place a custody seal on the jar and lid, and secure the seal in place with clear tape.
7. Use the chain-of-custody form to document the types and number of sediment samples collected and logged.
8. Record the time and date of sample collection, as well as a description of the sample and any associated air monitoring measurements, in the field logbook.
9. Decontaminate sampling equipment as per E & E's *Equipment Decontamination SOP*.

The following procedure is used to collect surface samples from rivers or from deeper lakes and ponds:

1. The sampler should select the sampling location farthest downstream for the first sample and work upstream. This will reduce the potential for disturbed sediments to migrate downstream to unsampled locations.
2. Using a precleaned sediment dredge or grab sampler, lower the sampler to the sediment layer with a polypropylene rope. Depending on the type of sampler used, the jaws of the sediment dredge will either automatically close, or will be triggered with a weighted messenger.
3. Recover the sampler and empty the sediment sample into a precleaned stainless-steel bowl. The water layer should be decanted slowly until only sediment remains in the bowl.
4. Using a precleaned stainless-steel spoon, remove the required volume of sediment. Place the sample in the appropriate precleaned glass jar, and secure the Teflon-lined lid to the jar.
5. Carefully and clearly identify the jar with the appropriate sample label, ensuring that all of the categories or parameters listed in Section 10.1.1 have been addressed. Place a custody seal on the jar and lid, and secure



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the seal in place with clear tape. The clear tape should cover the sample label.

6. Use the chain-of-custody form to document the types and number of sediment samples collected for shipment to a laboratory for analyses.
7. Record the time and date of sample collection, as well as a description of the sample and any associated air monitoring measurements, in the field logbook.
8. Decontaminate sampling equipment in accordance with E & E's *Equipment Decontamination SOP*.

The following procedure is used to collect subsurface samples from rivers or from deeper lakes and ponds:

1. The sampler should select the sampling location farthest downstream for the first sample and work upstream. This will reduce the potential for disturbed sediments to migrate downstream to unsampled locations.
2. Attach a precleaned gravity or mechanical coring device to the required length of polypropylene sample line and allow the corer to freefall through the water to the bottom.
3. Determine the depth of sediment penetration, and if acceptable, retrieve the corer with a smooth, continuous lifting motion.
4. Remove the overlying water from the corer by slowly pouring or siphoning it off near one side of the sampler. Remove the nosepiece from the corer, and slide the sample out of the corer into a stainless-steel bowl or tray.
5. Collect the necessary sample by cutting the core with the handle of a stainless-steel spoon, placing the sample in the appropriate precleaned glass jar, and securing the teflon-lined lid to the jar. Samples are handled in accordance with project-specific requirements.
6. Carefully and clearly label the jar with the appropriate sample tag, ensuring that all of the categories or parameters listed in Section 10.1.1 have been addressed. Place a custody seal on the jar and lid, and secure the seal in place with clear tape.



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7. Use the chain-of-custody form to document the types and number of sediment samples collected for shipment to a laboratory for analyses.
8. Record the time and date of sample collection, as well as a description of the sample and any associated air monitoring measurements, in the field logbook.
9. Decontaminate sampling equipment in accordance with E & E's *Equipment Decontamination SOP*.

8.4 Postoperations

1. Decontaminate all equipment according to E & E's *Equipment Decontamination SOP* prior to shipping the equipment back to the warehouse.
2. Organize field notes into the report format required by E & E's *Field Report Preparation SOP*. Logbooks should be maintained according to E & E's *Field Activities Log Book SOP*.
3. All samples should be shipped on the same day that they were collected to arrive at the laboratory not more than 24 hours after the samples were collected in accordance with E & E's *Sample Packaging SOP*.

9. Calculations

There are no specific calculations required for sediment sampling.

10. Quality Assurance

10.1 Sample Documentation

10.1.1 Sediment Sample Label

All sediment samples shall be documented in accordance with standard labeling techniques and project-specific requirements. The sediment sample label is completed to the fullest possible extent, prior to collecting the sample, and should contain the following minimum information:



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- Site name or identification;
- Sample location and identifier;
- Date sample was collected in a day, month, year format (e.g., 03 JUN 91 for June 3, 1991);
- Time of sample collection, using 24-hour clock in the hours: minutes format; and
- Analysis required.

10.1.2 Logbook

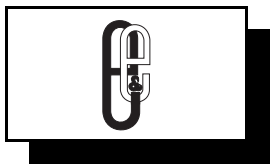
A bound field logbook will be maintained by field personnel to record daily activities in accordance with E & E's *Field Activities Logbooks* SOP and include sample collection, tracking, and shipping information. A separate entry will be made for each sample collected. These entries should include information from the sample label and a complete description of the location from which the sediment sample was collected.

10.1.3 Chain-of-Custody

Use the chain-of-custody form to document the types and number of sediment samples collected and logged.

10.2 Sampling Plan Design

- Many of the activities critical to ensuring that the collected samples are of high quality take place in the pre-collection planning and preparation stage. Careful planning and attention to detail at this stage will result in a more successful sampling effort, and will ensure collection of the highest quality samples possible. Since site and sampling conditions vary widely, and no universal sampling procedure can be recommended, a detailed sampling plan, consistent with the objectives of the study, must be developed prior to any sampling activities.
- Any of the sampling methods described here should allow a representative sediment sample to be obtained if the sampling plan is properly designed.
- Consideration must also be given to the collection of a sample representative of all horizons present in the sediment. Selection of the proper sampling device will facilitate this procedure.



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- A stringent quality assurance project plan (QAPP) should be outlined before any sampling operation is attempted. This should include, but not be limited to, the use of properly cleaned samplers and sample containers, chain-of-custody procedures, and collection of quality assurance samples such as field blanks, trip blanks, and duplicate samples.

11. Data Validation

The data generated will be reviewed according to quality assurance (QA) considerations identified in Section 10.

12. Health and Safety

Depending on site-specific contaminants, various protective programs must be implemented prior to sediment sampling. The site safety plan should be reviewed with specific emphasis placed on a protection program planned for direct contact tasks. Standard safe operating practices should be followed, including minimizing contact with potential contaminants in both vapor and solid matrix by using both respirators and disposable clothing.

Use appropriate safe work practices for the type of contaminant expected (or determined from previous sampling efforts):

Particulate or Metals Contaminants

- Avoid skin contact with and incidental ingestion of dust. Wash hands and other exposed skin areas routinely.
- Use protective gloves when collecting and handling the sediment samples.

Volatile Organic Contaminants

- Hexane acts as a carrier for a number of semivolatile organic compounds. The presence of hexane vapors in the air while decontaminating samplers indicates that the potential for exposure exists.
- If monitoring results indicate the presence of organic vapors, sampling activities must be conducted in Level C protection.



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- Acetone can penetrate some types of surgical gloves; use the appropriate gloves, such as Scorpio neoprene gloves, when handling acetone.

13. References

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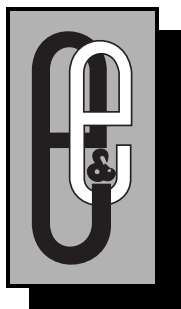
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STANDARD OPERATING PROCEDURE

SOIL SAMPLING

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1. Introduction

This document describes the procedures for the collection of representative soil samples. Representative sampling ensures the accurate characterization of site conditions. Analysis of soil samples may determine pollutant concentrations and the accompanying risks to public health, welfare, or the environment.

2. Scope

Included in this discussion are procedures for obtaining representative samples, quality assurance/quality control (QA/QC) measures, proper documentation of sampling activities, and recommendations for personnel safety.

3. Method Summary

Soil samples may be recovered using a variety of methods and equipment. These are dependent on the depth of the desired sample, the type of sample required (disturbed vs. undisturbed), and the soil type.

Samples of near-surface soils may be easily obtained using a spade, stainless-steel spoon, trowel, or scoop. Sampling at greater depths may be performed using a hand auger, a power auger, or, if a test pit is required, a backhoe.

All sampling devices should be cleaned using pesticide-grade acetone (assuming that acetone is not a target compound) or methanol, then wrapped in clean aluminum foil, and custody sealed for identification. The sampling equipment should remain in this wrapping until it is needed. Each sampler should be used for one sample only. However, dedicated tools may be impractical if there are a large number of soil samples required. In this case, samplers should be cleaned in the field using standard decontamination procedures as outlined in E & E's SOP for Equipment Decontamination (see ENV 3.15).

4. Sample Preservation, Containers, Handling, and Storage

The chemical preservation of solids is not generally recommended. Refrigeration is usually the best approach, supplemented by a minimal holding time.

Soil samples should be handled according to the procedures outlined in E & E's SOP for Sample Packaging and Shipping (see ENV 3.16).

5. Potential Problems

Potential problems with soil sampling include cross-contamination of samples and improper sample collection. Cross-contamination problems can be eliminated or minimized through the use of dedicated sampling equipment and bottles. If this is not possible or practical, then decontamination of sampling equipment is necessary. Improper sample collection is generally the result of the use of

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contaminated equipment; the disturbance of the matrix, resulting in compaction of the sample; and inadequate homogenization of the sample where required, resulting in variable, nonrepresentative results. Specific advantages and disadvantages of soil sampling equipment are presented in Table 5-1.

Table 5-1**SOIL SAMPLING EQUIPMENT**

Equipment	Applicability	Advantages and Disadvantages
Trier	Soft surface soil	Inexpensive; easy to use and decontaminate; difficult to use in stony, dry, or sandy soil.
Scoop, trowel, spoon, or spatula	Soft surface soil	Inexpensive; easy to use and decontaminate; trowels with painted surfaces should be avoided.
Tulip bulb planter	Soft soil, 0 to 6 inches	Easy to use and decontaminate; uniform diameter and sample volume; preserves soil core (suitable for VOA and undisturbed sample collection); limited depth capability; not useful for hard soils.
Spade or shovel	Medium soil, 0 to 12 inches	Easy to use and decontaminate; inexpensive; can result in sample mixing and loss of VOCs.
Vehimeyer soil outfit	Soil, 0 to 10 feet	Difficult to drive into dense or hard material; can be difficult to pull from ground.
Soil coring device and auger	Soft soil, 0 to 24 inches	Relatively easy to use; preserves soil core (suitable for VOA and undisturbed sample collection); limited depth capability; can be difficult to decontaminate.
Thin-walled tube sampler	Soft soil, 0 to 10 feet	Easy to use; preserves soil core (suitable for VOA and undisturbed sample collection); may be used to help maintain integrity of VOA samples; easy to decontaminate; can be difficult to remove cores from sampler.
Split-spoon sampler	Soil, 0 inches to bedrock	Excellent depth range; preserves soil core (suitable for VOA and undisturbed sample collection); acetate sleeve may be used to help maintain integrity of VOA samples; useful for hard soils; often used in conjunction with drill rig for obtaining deep cores.
Shelby tube sampler	Soft soil, 0 inches to bedrock	Excellent depth range; preserves soil core (suitable for VOA and undisturbed sample collection); tube may be used to ship sample to lab undisturbed; may be used in conjunction with drill rig for obtaining deep cores and for permeability testing; not durable in rocky soils.
Laskey sampler	Soil, 0 inches to bedrock	Excellent depth range; preserves soil cores; used in conjunction with drill rig for obtaining deep core; can be difficult to decontaminate.
Bucket auger	Soft soil, 3 inches to 10 feet	Easy to use; good depth range; uniform diameter and sample volume; acetate sleeve may be used to help maintain integrity of VOA samples; may disrupt and mix soil horizons greater than 6 inches in thickness.
Hand-operated power auger	Soil, 6 inches to 15 feet	Good depth range; generally used in conjunction with bucket auger for sample collection; destroys soil core (unsuitable for VOA and undisturbed sample collection); requires two or more equipment operators; can be difficult to decontaminate; requires gasoline-powered engine (potential for cross-contamination).
Continuous-flight auger	Soil, 0 inches to bedrock	Excellent depth range; easy to decontaminate; can be used on all soil samples; results in soil mixing and loss of VOCs.

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Table 5-1**SOIL SAMPLING EQUIPMENT**

Equipment	Applicability	Advantages and Disadvantages
Dutch auger	Designed specifically for wet, fibrous, or rooted soils (e.g., marshes)	
Eijkelcamp stoney soil auger	Stoney soils and asphalt	
Backhoe	Soil, 0 inches to 10 feet	Good depth range; provides visual indications as to depth of contaminants; allows for recovery of samples at specific depths; can result in loss of VOCs and soil mixing; shoring required at depth.

Note: Samplers may not be suitable for soils with coarse fragments.
Augers are suitable for soils with limited coarse fragments; only the stoney auger will work well in very gravelly soil.

6. Soil Sampling Equipment

Soil Sampling Equipment List

- Stainless-steel spoon
- Trier
- Scoop
- Trowel
- Spatula
- Stainless-steel tulip bulb planter
- Spade or shovel
- Vehimeyer soil sampler outfit
 - tubes
 - points
 - drive head
 - drop hammer
 - fuller jack and grip
- Soil-coring device
- Thin-walled tube sampler
- Split-spoon sampler
- Shelby tube sampler
- Laskey sampler
- Bucket auger
- Hand-operated power auger
- Continuous-flight auger
- Dutch auger
- Eijkelcamp stoney soil auger
- Backhoe
- Hand auger with replaceable sleeves



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Sampling Support Equipment and Documentation List

- Sampling plan
- Sample location map
- Safety equipment, as specified in the Health and Safety Plan
- Decontamination supplies and equipment, as described in the Work Plan
- Compass
- Tape measure
- Survey stakes or flags
- Camera
- Stainless-steel buckets or bowls
- Sample containers, precleaned (i.e., I-Chem)
- Logbook
- Chain-of-custody forms
- Plastic sheet
- Soil gas probes
- Infiltrometer
- Pounding sleeve
- Extension rods
- T-handle

Labeling, Packaging, and Shipping Supplies

- Coolers
- Labels for sample containers and coolers (e.g., "fragile")
- Ice
- Plastic bags for sample containers and ice
- ESC paint cans and clamps for polychlorinated biphenyl (PCB) sampling
- Vermiculite
- Duct and strapping tape
- Federal Express airbills and pouches

6.1 Geophysical Equipment

Geophysical techniques can be integrated with field analytical and soil sampling equipment to help define areas of subsurface contamination. For a description of the geophysical techniques and associated applications, refer to E & E's SOP for Surface Geophysical Techniques (see GEO 4.2).

7. Reagents

This procedures does not require the use of reagents except for decontamination of equipment, as required. Refer E & E's SOP for Equipment Decontamination (see ENV 3.15) and the Site-Specific Work Plan (SSWP) for proper decontamination procedures and appropriate solvents.



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8. Procedures

8.1 Office Preparation

1. The preparation of a Health and Safety Plan is required prior to any sampling. The plan must be approved and signed by the Corporate Health and Safety Officer or his/her designee (i.e., the Regional Safety Coordinator [RSC]).
2. Prepare a sampling plan to meet the data quality objectives (DQO) of the project in accordance with contract requirement. Review available background information (i.e., topographic maps, soil survey maps, geologic maps, other site reports, etc.) to determine the extent of the sampling effort, the sampling method to be employed, and the type and amounts of equipment and supplies required.
3. Obtain necessary sampling and monitoring equipment (see Section 6), decontaminate or preclean the equipment, and ensure that it is in working order.
4. Contact delivery service to confirm ability to ship all equipment and samples. Determine if shipping restrictions exist.
5. Prepare schedules and coordinate with staff, clients, and regulatory agencies, if appropriate.

8.2 Field Preparation

1. Identify local suppliers of sampling expendables (e.g., ice, plastic bags) and overnight delivery services (e.g., Federal Express).
2. Decontaminate or preclean all equipment before soil sampling, as described in E & E's SOP for Equipment Decontamination (see ENV 3.15), or as deemed necessary.
3. A general site survey should be performed prior to site entry in accordance with the Health and Safety Plan followed by a site safety meeting.
4. Identify and stake all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. All staked locations will be utility-cleared by the property owner or field team prior to soil sampling.

8.3 Representative Sample Collection

The objective of representative sampling is to ensure that a sample or group of samples adequately reflect site conditions.

8.3.1 Sampling Approaches

It is important to select an appropriate sampling approach for accurate characterization of site conditions. Each approach is defined below. Table 8-1 summarizes the following sampling approaches and ranks them from most to least suitable based on the sampling objective.



Table 8-1

REPRESENTATIVE SAMPLING APPROACH COMPARISON

Sampling Objective	Judgmental	Random	Stratified Random	Systematic Grid	Systematic Random	Search	Transect
Establish Threat	1	4	3	2 ^a	3	3	2
Identify Sources	1	4	2	2 ^a	3	2	3
Delineate Extent of Contamination	4	3	3	1 ^b	1	1	1
Evaluate Treatment and Disposal Options	3	3	1	2	2	4	2
Confirm Cleanup	4	1 ^c	3	1 ^b	1	1	1 ^c

1 Preferred approach.

2 Acceptable approach.

3 Moderately acceptable approach.

4 Least acceptable approach.

a Should be used with field analytical screening.

b Preferred only where known trends are present.

c Allows for statistical support of cleanup verification if sampling over entire site.

d May be effective with compositing techniques if site is presumed to be clean.

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8.3.1.1 Judgmental Sampling

Judgmental sampling is based on the subjective selection of sampling locations relative to historical site information, on-site investigation (site walk-over), etc. There is no randomization associated with this sampling approach because samples are collected primarily at areas of suspected highest contaminant concentrations. Therefore, any statistical calculations based on the sampling results would be unfairly biased.

8.3.1.2 Random Sampling

Random sampling involves the arbitrary collection of samples within a defined area. Refer to EPA 1984 and February 1989 for a random number table and guidelines on selecting sample coordinates. The arbitrary selection of sample locations requires each sample location to be chosen independently so that results in all locations within the area of concern have an equal chance of being selected. To facilitate statistical probabilities of contaminant concentration, the area of concern must be homogeneous with respect to the parameters being monitored. Thus, the higher the degree of heterogeneity, the less the random sampling approach will reflect site conditions (see Figure 8-1).

8.3.1.3 Stratified Random Sampling

Stratified random sampling relies primarily on historical information and prior analytical results to divide the area of concern into smaller sampling areas, or "strata." Strata can be defined by several factors, including: sampling depth, contaminant concentration levels, and contaminant source areas. Sampling locations should be selected within a strata using random selection procedures (see Figure 8-2).

8.3.1.4 Systematic Grid Sampling

Systematic grid sampling involves the division of the area of concern into smaller sampling areas using a square or triangular grid. Samples are then collected from the intersection of the grid lines, or "nodes." The origin and direction for placement of the grid should be selected by using an initial random point. The distance between nodes is dependent upon the size of the area of concern and the number of samples to be collected (see Figure 8-3).

8.3.1.5 Systematic Random Sampling

Systematic random sampling involves dividing the area of concern into smaller sampling areas as described in Section 8.3.1.4. Samples are collected within each grid cell using random selection procedures (see Figure 8-4).

8.3.1.6 Biased-Search Sampling

Search sampling utilizes a systematic grid or systematic random sampling approach to define areas where contaminants exceed cleanup standards (i.e., hot spots). The distance between the grid lines and number of samples to be collected are dependent upon the acceptable level of error (i.e., the chance of missing a hot spot). This sampling approach requires that assumptions be made regarding the size, shape, and depth of hot spots (see Figure 8-5).



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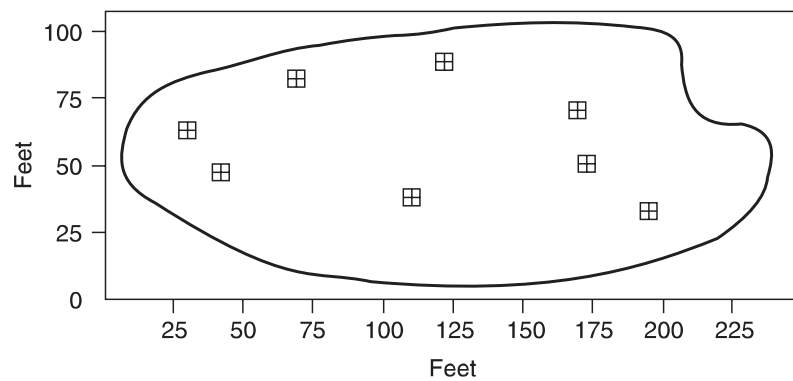


Figure 8-1 RANDOM SAMPLING**

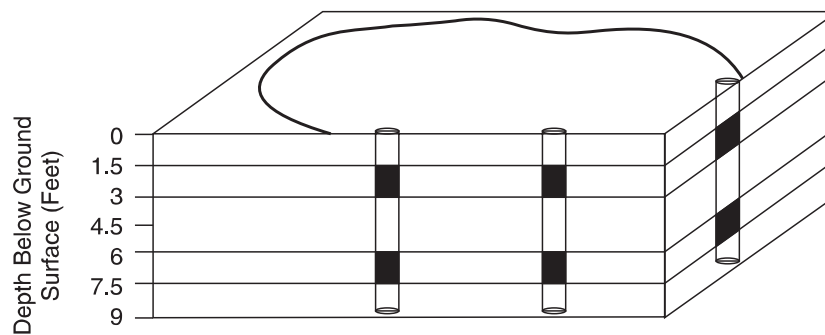


Figure 8-2 STRATIFIED RANDOM SAMPLING

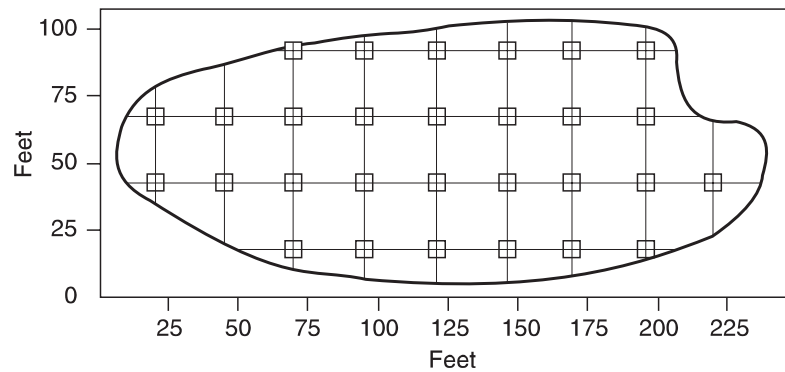


Figure 8-3 SYSTEMATIC GRID SAMPLING**

** After EPA, February 1989

Legend	
—	Sample Area Boundary
⊠	Selected Sample Location
■	Sample Location



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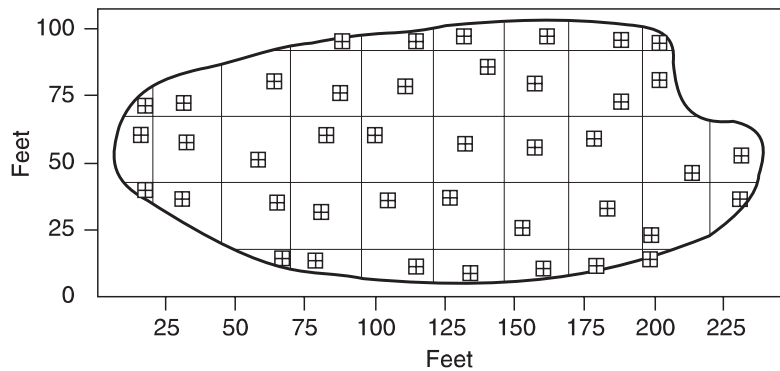


Figure 8-4 SYSTEMATIC RANDOM SAMPLING

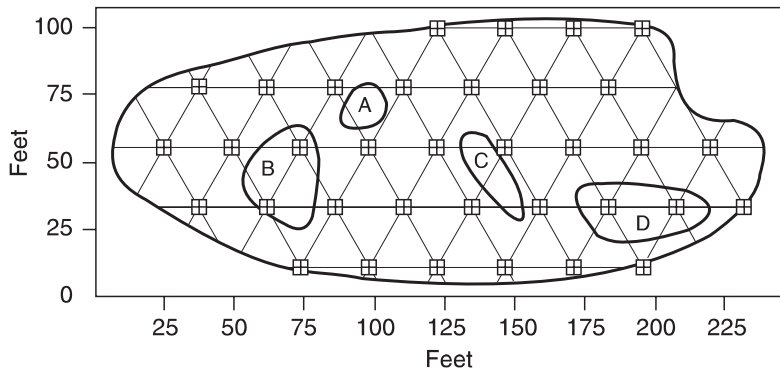


Figure 8-5 SEARCH SAMPLING

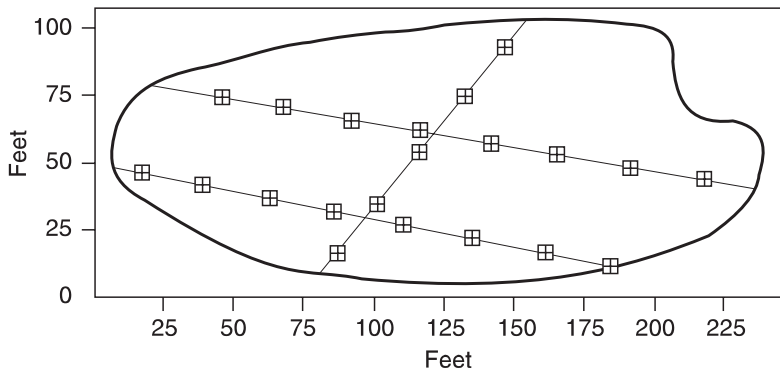
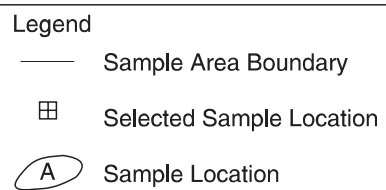


Figure 8-6 TRANSECT SAMPLING

After EPA, February 1989



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8.3.1.7 Transect Sampling

Transect sampling involves establishing one or more transect lines, parallel or nonparallel, across the area of concern. If the lines are parallel, this sampling approach is similar to systematic grid sampling. The advantage of transect sampling over systematic grid sampling is the relative ease of establishing and relocating transect lines as opposed to an entire grid. Samples are collected at regular intervals along the transect line at the surface and/or at a specified depth(s). The distance between the sample locations is determined by the length of the line and the number of samples to be collected (see Figure 8-6).

8.3.2 Surface Soil Samples

Collection of samples from near-surface soil can be accomplished with tools such as spades, spoons, shovels, and scoops. The surface material can be removed to the required depth with this equipment; stainless-steel or plastic scoops can then be used to collect the sample.

This method can be used in most soil types, but is limited to sampling near-surface areas. Accurate, representative samples can be collected with this procedure, depending on the care and precision demonstrated by the sampling technician. The use of a flat, pointed mason trowel to cut a block of the desired soil can be helpful when undisturbed profiles are required (e.g., for volatile organic analysis [VOAs]). A stainless-steel scoop, lab spoon, or plastic spoon will suffice in most other applications. Care should be exercised to avoid the use of devices plated with chrome or other materials, as is common with garden implements such as potting trowels.

Soil samples are collected using the following procedure:

1. Carefully remove the top layer of soil to the desired sample depth with a precleaned spade;
2. Using a precleaned, stainless-steel scoop, spoon, trowel, or plastic spoon, remove and discard the thin layer of soil from the area that came into contact with the shovel;
3. Transfer the sample into an appropriate container using a stainless-steel or plastic lab spoon or equivalent. If composite samples are to be collected, place the soil sample in a stainless-steel or plastic bucket and mix thoroughly to obtain a homogeneous sample representative of the entire sampling interval. Place the soil samples into labeled containers. **(Caution: Never composite VOA samples);**
4. VOA samples should be collected directly from the bottom of the hole before mixing the sample to minimize volatilization of contaminants;
5. Check to ensure that the VOA vial teflon liner is present in the cap, if required. Fill the VOA vial fully to the top to reduce headspace. Secure the cap tightly. The chemical preservation of solids is generally not recommended. Refrigeration is usually the best approach, supplemented by a minimal holding time;
6. Ensure that a sufficient sample size has been collected for the desired analysis, as specified in the Sampling Plan;
7. Decontaminate equipment between samples according to E & E's SOP for Equipment Decontamination (see ENV 3.15); and



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8. Fill in the hole and replace grass turf, if necessary.

QA/QC samples should be collected as specified, according to the Work Plan.

8.3.3 Sampling at Depth with Augers and Thin-Walled Tube Samplers

This system consists of an auger, a series of extensions, a T-handle, and a thin-walled tube. The auger is used to bore a hole to a desired sampling depth and is then withdrawn. The auger tip is then replaced with a tube core sampler, lowered down the borehole, and driven into the soil to the completion depth. The core is then withdrawn and the sample is collected.

Several augers are available, including: bucket type, continuous flight (screw), and posthole augers. Because they provide a large volume of sample in a short time, bucket types are better for direct sample recovery. When continuous-flight augers are used, the sample can be collected directly off the flights, usually at 5-foot intervals. The continuous-flight augers are satisfactory for use when a composite of the complete soil column is desired. Posthole augers have limited utility for sample collection, as they are designed to cut through fibrous, rooted, swampy soil.

The following procedures will be used for collecting soil samples with the hand auger:

1. Attach the auger bit to a drill rod extension, and attach the T-handle to the drill rod.
2. Clear the area to be sampled of any surface debris (e.g., twigs, rocks, litter). It may be advisable to remove the first 3- to 6-inches of surface soil from an area approximately 6 inches in radius around the drilling location.
3. Begin augering, periodically removing and depositing accumulated soils onto a canvas or plastic sheet spread near the hole. This prevents accidental brushing of loose material back down the borehole when removing the auger or adding drill rods. It also facilitates refilling the hole and avoids possible contamination of the surrounding area.
4. After reaching the desired depth, slowly and carefully remove the auger from the boring. When sampling directly from the auger, collect the sample after the auger is removed from boring and proceed to Step 11.
5. A precleaned stainless-steel auger sleeve can also be used to collect a sample. After reaching the desired sampling depth, remove the auger and place the sleeve inside the auger. Collect the sample with the auger. Remove the auger from the boring. The sample will be collected only from the sleeve. The soil from the auger tip should never be used for the sample.
6. Remove auger tip from drill rods and replace with a precleaned thin-walled tube sampler. Install proper cutting tip.
7. Carefully lower the tube sampler down the borehole. Gradually force the tube sampler into soil. Care should be taken to avoid scraping the borehole sides. Avoid hammering the drill rods to facilitate coring, as the vibrations may cause the boring walls to collapse.
8. Remove the tube sampler and unscrew the drill rods.
9. Remove the cutting tip and core from the device.



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10. Discard the top of the core (approximately 1 inch), as this represents material collected before penetration of the layer in question. Place the remaining core into the sample container.
11. If required, ensure that a teflon liner is present in the cap. Secure the cap tightly onto the sample container. Place the sample bottle in a plastic bag and put on ice to keep the sample at 4°C.
12. Carefully and clearly label the container with the appropriate sample tag, addressing all the categories or parameters listed in E & E's SOP for Sample Packaging and Shipping (see ENV 3.16).
13. Use the chain-of-custody form to document the types and numbers of soil samples collected and logged. Verify that the chain-of-custody form is correctly and completely filled out.
14. Record the time and date of sample collection, as well as a description of the sample in the field logbook.
15. If another sample is to be collected in the sample hole, but at a greater depth, re-attach the auger bit to the drill and assembly, and follow steps 3 through 11, making sure to decontaminate the auger and tube sampler between samples.
16. Abandon the hole according to applicable regulations. Generally, shallow holes can simply be backfilled with the removed soil material.
17. Decontaminate the sampling equipment as per E & E's SOP for Equipment Decontamination (see ENV 3.15).

8.3.4 Sampling at Depth with a Trier

1. Insert the trier into the material to be sampled at a 0° to 45° angle from horizontal. This orientation minimizes the spillage of sample material. Extraction of samples may require tilting of the containers.
2. Rotate the trier once or twice to cut a core of material.
3. Slowly withdraw the trier, making sure that the slot is facing upward.
4. Transfer the sample into a suitable container with the aid of a spatula and brush.
5. If required, ensure that a teflon liner is present in the cap. Secure the cap tightly onto the sample container. Samples are handled in accordance with E & E's SOP for Sample Packaging and Shipping (see ENV 3.16).
6. Carefully and clearly label the container with the appropriate sample tag, addressing all the categories or parameters listed in E & E's SOP for Sample Packaging and Shipping (see ENV 3.16).
7. Use the chain-of-custody form to document the types and numbers of soil samples collected and logged.



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8. Record the time and date of sample collection as well as a description of the sample and any associated air monitoring measurements in the field logbook.
9. Abandon the hole according to applicable regulations. Generally, shallow holes can simply be backfilled with the removed soil material.
10. Decontaminate sampling equipment as per E & E's SOP for Equipment Decontamination (see ENV 3.15).

8.3.5 Sampling at Depth with a Split-Spoon (Barrel) Sampler

The procedure for split spoon sampling describes the extraction of undisturbed soil cores of 18 or 24 inches in length. A series of consecutive cores may be sampled to give a complete soil column, or an auger may be used to drill down to the desired depth for sampling. The split spoon is then driven to its sampling depth through the bottom the augured hole and the core extraction.

This sampling device may be used to collect information such as soil density. All work should be performed in accordance with ASTM D 1586-84, *Penetration Test and Split Barrel Sampling of Soils*.

1. Assemble the sampler by aligning both sides of the barrel and then screwing the bit on the bottom and the heavier head piece on top. Install a retaining cap in the head piece if necessary.
2. Place the sampler in a perpendicular position on the sample material.
3. Using a sledge hammer or well ring, if available, drive the tube. Do not drive past the bottom of the head piece or compression of the sample will result.
4. Record the length of the tube used to penetrate the material being sampled and the number of blows required to obtain this depth.
5. Withdraw the split spoon and open by unscrewing the bit and head. If a split sample is desired, a clean stainless-steel knife should be used to divide the tube contents in half, lengthwise. This sampler is available in 2- and 3.5-inch diameters. The required sample volume may dictate the use of the larger barrel. If needed, stainless-steel or teflon sleeves can be used inside the split spoon. If sleeves removed from the split spoon are capped immediately, volatilization of contaminants can be reduced. When split spoon sampling is performed to gain geologic information, all work should be performed in accordance with ASTM D 1586-67 (reapproved 1974).
6. Cap the sample container, place in a double plastic bag and attach the label and custody seal. Record all pertinent data in the field logbook and complete the sample analysis request form and chain-of-custody record before taking the next sample.
7. If required, preserve or place the sample on ice.
8. Follow proper decontamination procedures and deliver samples to the laboratory for analysis.



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8.3.6 Test Pit/Trench Excavation

These relatively large excavations are used to remove sections of soils when detailed examination of soil characteristics (horizontal, structure, color, etc.) are required. It is the least cost-effective sampling method due to the relatively high cost of backhoe operation.

1. Prior to any excavations with a backhoe, it is important to ensure that all sampling locations are clear of utility lines and poles (subsurface as well as above surface).
2. Using the backhoe, a trench is dug to approximately 3 feet in width and approximately 1 foot below the cleared sampling depth. Place removed or excavated soils on canvas or plastic sheets, if necessary. Trenches greater than 4 feet deep must be sloped or protected by a shoring system, as required by OSHA regulations.
3. A shovel is used to remove a 1- to 2-inch layer of soil from the vertical face of the pit where sampling is to be done.
4. Samples are taken using a trowel, scoop, or coring device at the desired intervals. Be sure to scrape the vertical face at the point of sampling to remove any soil that may have fallen from above, and to expose soil for sampling. Samples are removed and placed in an appropriate container.
5. If required, ensure that a teflon liner is present in the cap. Secure the cap tightly onto the sample container. Samples are handled in accordance with E & E's SOP for Sample Packaging and Shipping (see ENV 3.16).
6. Carefully and clearly label the container with the appropriate sample tag, addressing all the categories or parameters listed in E & E's SOP for Sample Packaging and Shipping (see ENV 3.16).
7. Use the chain-of-custody form to document the types and numbers of soil samples collected and logged.
8. Record the time and date of sample collection as well as a description of the sample and any associated air monitoring measurements in the field logbook.
9. Abandon the hole according to applicable State regulations. Generally, excavated holes can simply be backfilled with the removed soil material.
10. Decontaminate sampling equipment, including the backhoe bucket, as per E & E's SOP for Equipment Decontamination (see ENV 3.15).

8.4 Sample Preparation

In addition to sampling equipment, representative sample collection includes sample quantity, volume, preservation, and holding time (see Table 8-2). Sample preparation refers to all aspects of sample handling after collection. How a sample is prepared can affect its representativeness. For example, homogenizing can result in a loss of volatiles and is therefore inappropriate when volatile contaminants are the concern.



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Table 8-2

STANDARD SAMPLE HOLDING TIMES, PRESERVATION METHODS, AND VOLUME REQUIREMENTS

Protocol Parameter	Holding Time		Minimum Volume Required		Container Type		Preservation	
	Soil	Water	Soil	Water	Soil	Water	Soil	Water
SW-846								
VOA ^e	14 days from date sampled	14 days from date sampled	15 g	One 40 ml vial; no air space	Two 40 ml vials; no air space	Two 40 ml vials; no air space	Cool to 4 °C (ice in cooler)	Add HCl until pH <2 and cool to 4 °C (ice in cooler)
Semi-VOA (BNAs) ^e	14 days to extract from date sampled	7 days to extract from date sampled	30 g	1 L	8 oz. glass jar with Teflon-lined cap	1/2 gallon amber glass bottle	Cool to 4 °C (ice in cooler)	Cool to 4 °C (ice in cooler)
PCBs ^{d,e}	14 days to extract from date sampled	7 days to extract from date sampled	30 g	1 L	4 oz. glass jar with Teflon-lined cap	1/2 gallon amber glass bottle	Cool to 4 °C (ice in cooler)	Cool to 4 °C (ice in cooler)
Pesticides/PCBs ^{d,e}	14 days to extract from date sampled	7 days to extract from date sampled	30 g	1 L	8 oz. glass jar with Teflon-lined cap	1/2 gallon amber glass bottle	Cool to 4 °C (ice in cooler)	Cool to 4 °C (ice in cooler)
Metals ^c	6 months from date sampled	6 months from date sampled	10 g	300 ml	8 oz. glass jar with Teflon-lined cap	1 L polyethylene bottle with polyethylene-lined cap	Cool to 4 °C (ice in cooler)	Add HNO ₃ until pH <2 and cool to 4 °C (ice in cooler)
Cyanide ^e	14 days from date sampled	14 days from date sampled	10 g	100 ml	8 oz. glass jar with Teflon-lined cap	1 L polyethylene bottle with polyethylene-lined cap	Cool to 4 °C (ice in cooler)	Add NaOH until pH >12 and cool to 4 °C (ice in cooler)
Hexavalent chromium ^a	24 hours from time sampled	24 hours from time sampled	10 g	50 ml	8 oz. glass jar with Teflon-lined cap	125 ml polyethylene bottle with polyethylene-lined cap	Cool to 4 °C (ice in cooler)	Cool to 4 °C (ice in cooler)
Total Organic Carbon (TOC) ^a	NA	28 days from date sampled	5 g	10 ml	8 oz. glass jar with Teflon-lined cap	125 ml polyethylene bottle with polyethylene-lined cap	Cool to 4 °C (ice in cooler)	Add H ₂ SO ₄ until pH <2 and cool to 4 °C (ice in cooler)

Key at end of table.

Table 8-2

STANDARD SAMPLE HOLDING TIMES, PRESERVATION METHODS, AND VOLUME REQUIREMENTS

Protocol Parameter	Holding Time		Minimum Volume Required		Container Type		Preservation	
	Soil	Water	Soil	Water	Soil	Water	Soil	Water
Total Organic Halides (TOX) ^{a,e}	NA	7 days from date sampled	100 g	200 ml	8 oz. glass jar with Teflon-lined cap	1 L amber glass bottle	Cool to 4 °C (ice in cooler)	Add H ₂ SO ₄ until pH <2 and cool to 4 °C (ice in cooler)
Total Recoverable Petroleum Hydrocarbons ^e	28 days from date sampled	28 days from date sampled	50 g	1 L	8 oz. glass jar with Teflon-lined cap	1 L amber glass bottle	Cool to 4 °C (ice in cooler)	Add H ₂ SO ₄ until pH <2 and cool to 4 °C (ice in cooler)
USEPA-CLP								
VOA ^e	10 days from date received	10 days from date received	15 g	One 40 ml vial; no air space	Two 40 ml vials; no air space	Two 40 ml vials; no air space	Cool to 4 °C (ice in cooler)	Add HCl until pH <2 and cool to 4 °C (ice in cooler)
Semi-VOA (BNAs) ^e	10 days to extract from date received	5 days to extract from date received	30 g	1 L	8 oz. glass jar with Teflon-lined cap	1/2 gallon amber glass bottle	Cool to 4 °C (ice in cooler)	Cool to 4 °C (ice in cooler)
PCBs ^{d,e}	10 days to extract from date received	5 days to extract from date received	30 g	1 L	4 oz. glass jar with Teflon-lined cap	1/2 gallon amber glass bottle	Cool to 4 °C (ice in cooler)	Cool to 4 °C (ice in cooler)
Pesticides/PCBs ^{d,e}	10 days to extract from date received	5 days to extract from date received	30 g	1 L	8 oz. glass jar with Teflon-lined cap	1/2 gallon amber glass bottle	Cool to 4 °C (ice in cooler)	Cool to 4 °C (ice in cooler)
Metals ^c	6 months from date sampled	6 months from date sampled	10 g	300 ml	8 oz. glass jar with Teflon-lined cap	1 L polyethylene bottle with polyethylene-lined cap	Cool to 4 °C (ice in cooler)	Add HNO ₃ to pH <2 and cool to 4 °C (ice in cooler)
Cyanide ^e	12 days from date received	12 days from date received	10 g	100 ml	8 oz. glass jar with Teflon-lined cap	1 L polyethylene bottle with polyethylene-lined cap	Cool to 4 °C (ice in cooler)	Add NaOH to pH >12 and cool to 4 °C (ice in cooler)
NYSDEC-CLP								
VOA ^{b,e}	7 days from date received	10 days from date received	15 g	One 40 ml vial; no air space	Two 40 ml vials; no air space	Two 40 ml vials; no air space	Cool to 4 °C (ice in cooler)	Add HCl until pH <2 and cool to 4 °C (ice in cooler)
Semi-VOA (BNAs) ^e	5 days to extract from date received	5 days to extract from date received	30 g	1 L	8 oz. glass jar with Teflon-lined cap	1/2 gallon amber glass bottle	Cool to 4 °C (ice in cooler)	Cool to 4 °C (ice in cooler)

Key at end of table.



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Table 8-2

STANDARD SAMPLE HOLDING TIMES, PRESERVATION METHODS, AND VOLUME REQUIREMENTS

Protocol Parameter	Holding Time		Minimum Volume Required		Container Type		Preservation	
	Soil	Water	Soil	Water	Soil	Water	Soil	Water
PCBs ^{d,e}	5 days to extract from date received	5 days to extract from date received	30 g	1 L	4 oz. glass jar with Teflon-lined cap	1/2 gallon amber glass bottle	Cool to 4 °C (ice in cooler)	Cool to 4 °C (ice in cooler)
Pesticides/PCBs ^{d,e}	5 days to extract from date received	5 days to extract from date received	30 g	1 L	8 oz. glass jar with Teflon-lined cap	1/2 gallon amber glass bottle	Cool to 4 °C (ice in cooler)	Cool to 4 °C (ice in cooler)
Metals ^c	6 months from date sampled	6 months from date sampled	10 g	300 ml	8 oz. glass jar with Teflon-lined cap	1 L polyethylene bottle with polyethylene-lined cap	Cool to 4 °C (ice in cooler)	Add HNO ₃ to pH <2 and cool to 4 °C (ice in cooler)
Cyanide ^e	12 days from date received	12 days from date received	10 g	100 ml	8 oz. glass jar with Teflon-lined cap	1 L polyethylene bottle with polyethylene-lined cap	Cool to 4 °C (ice in cooler)	Add NaOH to pH >12 and cool to 4 °C (ice in cooler)
EPA Water and Waste								
Total dissolved solids (TDS)	NA	7 days from date sampled	NA	200 ml	NA	1 L polyethylene bottle with polyethylene-lined cap	NA	Cool to 4 °C (ice in cooler)

Note: All sample bottles will be prepared in accordance with EPA bottle-washing procedures. These procedures are incorporated in E & E's Laboratory and Field Personnel Chain-of-Custody Documentation and Quality Assurance/Quality Control Procedures Manual, July 1987.

- a Technical requirements for sample holding times have been established for water matrices only. However, they are also suggested for use as guidelines in evaluating soil data.
- b Holding time for GC/MS analysis is 7 days if samples are not preserved.
- c Maximum holding time for mercury is 28 days from time sampled.
- d If one container has already been collected for PCBs analysis, then only one additional container need be collected for extractable organics, BNAs, or pesticides/PCBs analysis.
- e Extra containers required for MS/MSD.

Key:

NA = Not applicable.



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8.4.1 Sample Quantity and Volume

The volume and number of samples necessary for site characterization will vary according to the budget, project schedule, and sampling approach.

8.4.2 Sample Preservation and Holding Time

Sample preservation and holding times are as discussed in Section 4.

8.4.3 Removing Extraneous Material

Discard materials in a sample that are not relevant for site or sample characterization (e.g., glass, rocks, and leaves), since their presence may introduce an error in analytical procedures.

8.4.4 Homogenizing Samples

Homogenizing is the mixing of a sample to provide a uniform distribution of the contaminants. Proper homogenization ensures that the containerized samples are representative of the total soil sample collected. All samples to be composited or split should be homogenized after all aliquots have been combined. Do not homogenize samples for volatile compound analysis.

8.4.5 Compositing Samples

Compositing is the process of physically combining and homogenizing several individual soil aliquots of the same volume or weight. Compositing samples provides an average concentration of contaminants over a certain number of sampling points. Compositing dilutes high concentration aliquots; therefore, detection limits should be reduced accordingly. If the composite area is heterogeneous in concentration and its composite value is to be compared to a particular action-level, then that action-level must be divided by the total number of aliquots making up the composite for accurate determination of the detection limit.

8.4.6 Splitting Samples

Splitting samples (after preparation) is performed when multiple portions of the same samples are required to be analyzed separately. Fill the sample containers simultaneously with alternate spoonfuls of the homogenized sample (see Figure 8-7).

8.5 Post-Operations

8.5.1 Field

Decontaminate all equipment according to E & E's SOP for Equipment Decontamination (see ENV 3.15).

8.5.2 Office

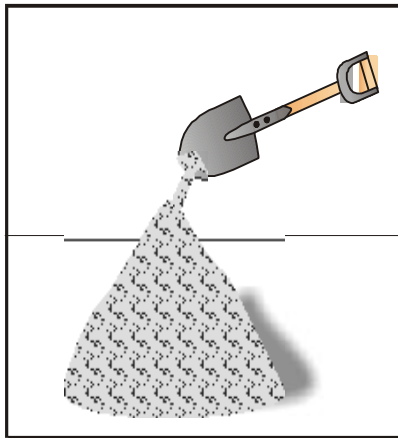
Organize field notes into a report format and transfer logging information to appropriate forms.



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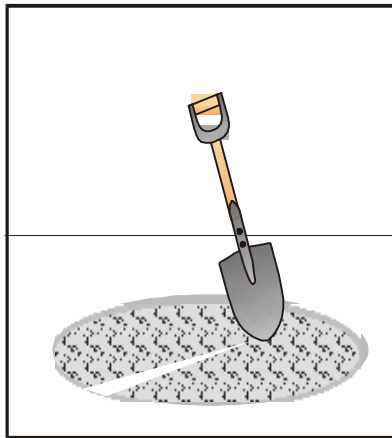
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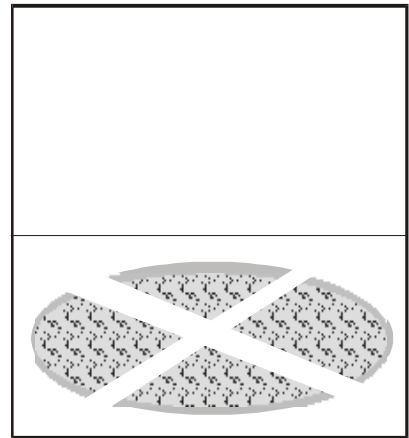
Step 1:

- Cone Sample on hard, clean surface
- Mix by forming new cone



Step 2:

- Quarter after flattening cone



Step 3:

- Divide sample into quarters

Step 4:

- Remix opposite quarters
- Reform cone
- Repeat a minimum of 5 times

After: ASTM Standard C702-87

Figure 8-7 Quartering to Homogenize and Split Samples



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9. Calculations

There are no specific calculations required for these procedures.

10. Quality Assurance/Quality Control

The objective of QA/QC is to identify and implement methodologies that limit the introduction of error into sampling and analytical procedures.

10.1 Sampling Documentation

10.1.1 Soil Sample Label

All soil samples shall be documented in accordance with E & E's SOP for Sample Packaging and Shipping (see ENV 3.16). The soil sample label is filled out prior to collecting the sample and should contain the following:

1. Site name or identification.
2. Sample location and identifier.
3. Date samples were collected in a day, month, year format (e.g., 03 Jan 88 for January 3, 1988).
4. Time of sample collection, using 24-hour clock in the hours: minutes format.
5. Sample depth interval. Units used for depths should be in feet and 10ths of feet.
6. Preservatives used, if any.
7. Analysis required.
8. Sampling personnel.
9. Comments and other relevant observations (e.g., color, odor, sample technique).

10.1.2 Logbook

A bound field notebook will be maintained by field personnel to record daily activities, including sample collection and tracking information. A separate entry will be made for each sample collected. These entries should include information from the sample label and a complete physical description of the soil sample, including texture, color (including notation of soil mottling), consistency, moisture content, cementation, and structure.

10.1.3 Chain-of-Custody

Use the chain-of-custody form to document the types and numbers of soil samples collected and logged. Refer to E & E's SOP for Sample Packaging and Shipping (see ENV 3.16) for directions on filling out this form.



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10.2 Sampling Design

1. Sampling situations vary widely; thus, no universal sampling procedure can be recommended. However, a sampling plan should be implemented before any sampling operation is attempted, with attention paid to contaminant type and potential concentration variations.
2. Any of the sampling methods described here should allow a representative soil sample to be obtained, if the sampling plan is properly designed.
3. Consideration must also be given to the collection of a sample representative of all horizons present in the soil. Selection of the proper sampler will facilitate this procedure.
4. A stringent QA project plan should be outlined before any sampling operation is attempted. This should include, but not be limited to, properly cleaned samplers and sample containers, appropriate sample collection procedures, chain-of-custody procedures, and QA/QC samples.

11. Data Validation

The data generated will be reviewed according to the QA/QC considerations that are identified in Section 10.

11.1 Quality Assurance/Quality Control Samples

QA/QC samples are used to identify error due to sampling and/or analytical methodologies and chain-of-custody procedures.

11.1.1 Field Duplicates (Replicates)

Field duplicates are collected from one location and treated as separate samples throughout the sample handling and analytical processes. These samples are used to assess total error for critical samples with contaminant concentrations near the action level.

11.1.2 Collocated Samples

Collocated samples are generally collected 1.5 to 3.0 feet away from selected field samples to determine both local soil and contaminant variations on site. These samples are used to evaluate site variation within the immediate vicinity of sample collection.

11.1.3 Background Samples

Background or "clean" samples are collected from an area upgradient from the contamination area and representative of the typical conditions. These samples provide a standard for comparison of on-site contaminant concentration levels.

11.1.4 Rinsate (Equipment) Blanks

Rinsate blanks are collected by pouring analyte-free water (i.e., laboratory de-ionized water) on decontaminated sampling equipment to test for residual contamination. These samples are used to assess potential cross contamination due to improper decontamination procedures.



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11.1.5 Performance Evaluation Samples

Performance evaluation samples are generally prepared by a third party, using a quantity of analyte(s) known to the preparer but unknown to the laboratory. The percentage of analyte(s) identified in the sample is used to evaluate laboratory procedural error.

11.1.6 Matrix Spike/Matrix Spike Duplicates (MS/MSD)

MS/MSD samples are spiked in the laboratory with a known quantity of analyte(s) to confirm percent recoveries. They are primarily used to check sample matrix interferences.

11.1.7 Field Blanks

Field blanks are prepared in the field with certified clean sand, soil, or water. These samples are used to evaluate contamination error associated with sampling methodology and laboratory procedures.

11.1.8 Trip Blanks

Trip blanks are prepared prior to going into the field using certified clean sand, soil, or water. These samples are used to assess error associated with sampling methodology and analytical procedures for volatile organics.

12. Health and Safety

12.1 Hazards Associated With On-Site Contaminants

Depending on site-specific contaminants, various protective programs must be implemented prior to soil sampling. The site Health and Safety Plan should be reviewed with specific emphasis placed on a protection program planned for direct-contact tasks. Standard safe operating practices should be followed, including minimization of contact with potential contaminants in both the vapor phase and solid matrix by using both respirators and disposable clothing.

Use appropriate safe work practices for the type of contaminant expected (or determined from previous sampling efforts):

- Particulate or Metals Contaminants
 - Avoid skin contact with, and ingestion of, soils and dusts.
 - Use protective gloves.
- Volatile Organic Contaminants
 - Pre-survey the site with an HNu 101 or OVA 128 prior to taking soil samples.
 - If monitoring results indicate organic constituents, sampling activities may be conducted in Level C protection. At a minimum, skin protection will be afforded by disposable protective clothing.



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13. References

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U.S. Environmental Protection Agency (EPA), 1984, *Characterization of Hazardous Waste Sites - A Methods Manual: Volume II, Available Sampling Methods*, (2nd ed.), 1984, EPA-600/4-84-076.

_____, 1991, *Removal Program Representative Sampling Guidance: Volume I - Soil*, (Interim Final), EPA-9360.4-10.

_____, 1984, *Characterization of Hazardous Waste Sites - A Methods Manual: Volume I, Site Investigations*, Section 7: Environmental Monitoring Systems Laboratory, Las Vegas, Nevada, EPA/600/4-84/075.

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A. Sampling Augers

A. Sampling Augers



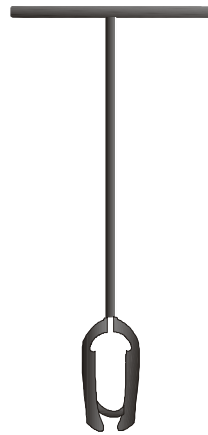
(a)
Ship Auger



(b)
Closed-Spiral Auger



(c)
Open-Spiral Auger

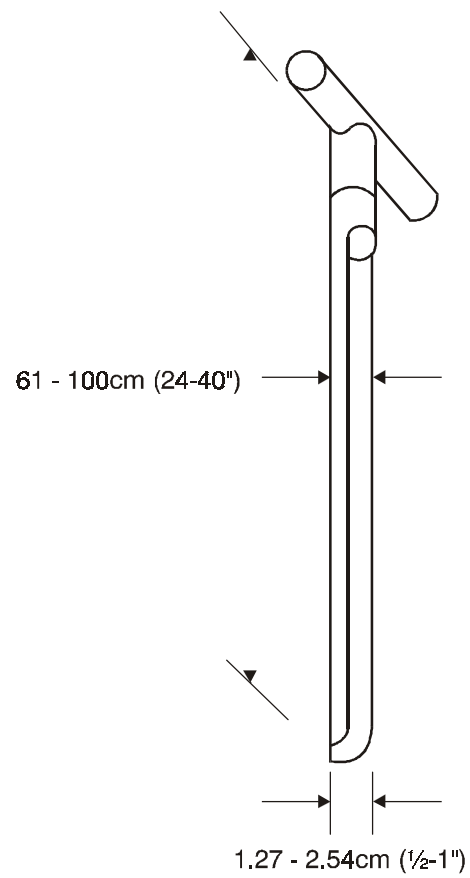


(d)
Iwan Auger



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B. Sampling Trier



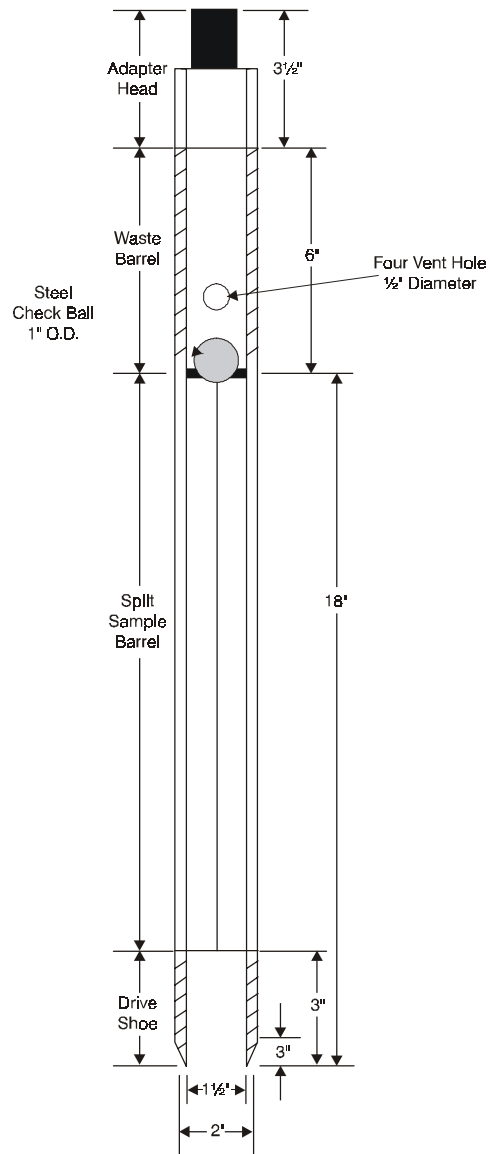


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C. Split-Spoon Sampler





TITLE:

SURFACE WATER SAMPLING

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SURFACE WATER SAMPLING

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1. Introduction

This Standard Operating Procedure (SOP) outlines recommended procedures and equipment for the collection of representative liquid samples (aqueous and nonaqueous) from streams, rivers, lakes, ponds, lagoons, and surface impoundments both at the surface and at various depths in the water column. This SOP does not pertain to the collection of groundwater samples.

2. Method Summary

Sampling situations vary widely and therefore, no universal sampling procedure can be recommended. A sampling plan must be completed before any sampling operation is attempted. The sampling plan should include objectives of the study, the number and type of samples required to meet these objectives, and procedures to collect these samples based on site characteristics.

The sampling of both aqueous and nonaqueous liquids from the above-mentioned sources is generally accomplished through the use of one of the following:

- Kemmerer bottle,
- Bacon bomb,
- Dip sampler, or
- Direct method.

These sampling techniques will allow for the collection of representative samples from the majority of surface water types and impoundments encountered.

3. Potential Problems

There are two primary potential problems associated with surface water sampling: cross-contamination of samples, and improper sample collection.

Cross-contamination problems can be eliminated or minimized through the use of dedicated sampling equipment and bottles. If this is not possible or practical, then decontamination of sampling equipment is necessary. See E & E's SOP on *Equipment Decontamination* (ENV 3.15).



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Improper sample collection can involve using contaminated equipment, disturbance of stream or impoundment substrate, and sampling in a disturbed area such as that caused by a boat wake. Following proper decontamination procedures and minimizing disturbance of the sample site will minimize or eliminate these problems.

4. Equipment

Equipment needed for collecting surface water samples includes:

- Kemmerer bottle,
- Bacon bomb,
- Dip sampler,
- Line and messengers,
- Sample bottles, preservative, ziploc bags, ice, coolers,
- Chain-of-custody seals and forms, field data sheets,
- Decontamination equipment,
- Protective clothing,
- Maps/plot plan,
- Safety equipment,
- Compass,
- Tape measure,
- Survey stakes, flags, or buoys and anchors,
- Camera and film,
- Logbook, and
- Sample bottle labels.



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5. Reagents

Reagents are commonly used to preserve samples and to decontaminate sampling equipment. Appropriate preservation and decontamination procedures should be selected prior to field sampling.

Preservatives commonly used include:

- Nitric acid (HNO_3) for metals analyses,
- Sodium hydroxide (NaOH) for cyanide analysis,
- Sulfuric acid (H_2SO_4) for TRPH analysis, and
- Hydrochloric acid (HCl) for VOC analysis.

Decontamination reagents include:

- Nitric acid (HNO_3),
- Acetone, and
- Deionized or distilled water.

6. Health and Safety

Personal safety is always the most important factor in any sampling operation. Sampling under unknown conditions should always be considered worst case, necessitating the selection of appropriate personal protection.

When sampling lagoons or surface impoundments containing known or suspected hazardous substances, adequate precautions must be taken to ensure the safety of sampling personnel. The sampling team member collecting the sample should not get too close to the edge of the impoundment, where bank failure may cause him/her to lose their balance. The person performing the sampling should be on a lifeline and wearing adequate protective equipment.

When conducting sampling from a boat in an impoundment or flowing waters, appropriate boating safety procedures will be followed.



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7. Procedures

7.1 Sampling Considerations

7.1.1 Preparation

Prior to the initiation of any sampling operation, the immediate area should be checked for radioactivity, volatile organic compounds (VOCs), photoionization potential, airborne dust, and explosivity, as required by the Site Safety Plan. The following steps should then be taken:

- Determine the extent of the sampling effort, the sampling methods to be employed, and the equipment and supplies needed;
- Obtain necessary sampling and monitoring equipment;
- Decontaminate or preclean equipment, and ensure that it is in working order;
- Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate; and
- Use stakes, flags, or buoys and anchors to identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

7.1.2 Representative Samples

In order to collect a representative sample, the hydrology and morphology of a stream or impoundment should be determined prior to sampling. This will aid in determining the presence of phases or layers in lagoons or impoundments, flow patterns in streams, and appropriate sample locations and depths. Additional information can be found in the references listed in Section 12.

Generally, the deciding factors in the selection of a sampling device for surface water sampling are:

- The depth and flow of surface water body,
- Location from where the sample will be collected, and
- The depth at which the sample(s) is to be collected.



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7.1.3 Sampler Composition

The sampling device must be constructed of the appropriate materials. Samplers constructed of glass, stainless steel, PVC, or PFTE (teflon) should be used, depending on the types of analyses to be performed (i.e., samples to be analyzed for metals should not be collected in metallic containers).

7.2 Sample Collection

7.2.1 Kemmerer Bottle

A Kemmerer bottle may be used in most situations where site access is from a boat or structure such as a bridge or pier, and where samples at depth are required. Sampling procedures are as follows:

- Using a properly decontaminated Kemmerer bottle, set the sampling device so that the sampling end pieces are pulled away from the sampling tube, allowing the substance to pass through this tube;
- Slowly lower the preset sampling device to the predetermined depth. Avoid bottom disturbance;
- When the Kemmerer bottle is at the required depth, send down the messenger, closing the sampling device; and
- Retrieve the sampler. Transfer sample to sample container.

7.2.2 Bacon Bomb

This type of sampler may be used in situations similar to those outlined for the Kemmerer bottle. Sampling procedures are as follows:

- Lower the bacon bomb sampler carefully to the desired depth, allowing the line for the trigger to remain slack at all times. When the desired depth is reached, pull the trigger line until taut; and
- Release the trigger line and retrieve the sampler. Transfer the sample to the sample container by pulling on the trigger.

7.2.3 Dip Sampler

A dip sampler is useful for situations in which a sample is to be recovered from an outfall pipe, such as through a storm sewer grating, or along a lagoon bank where direct accessibility is limited. The long handle on such a device allows access from a discrete location. The procedure is as follows:



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- Assemble the device in accordance with the manufacturer's instructions,
- Extend the device to the sample location and collect the sample, and
- Retrieve the sampler.

7.2.4 Direct Method

For streams, rivers, lakes, and other surface waters, the direct method may be utilized to collect water samples from the surface. This method is not to be used for sampling lagoons or other impoundments where contact with contaminants is a concern.

Using adequate protective clothing (i.e., gloves and hip waders), access the sampling station by appropriate means (wading or boat). For shallow stream stations, collect the sample under the water surface pointing the sample container upstream. The container must also be upstream of the collector. Avoid disturbing the substrate. For lakes and other impoundments, collect the sample under the water surface avoiding surface debris and the boat wake.

8. Sample Preservation, Containers, Handling, and Storage

Sample preservation, sample containers, sample handling, and sample storage are critical concerns for many types of analyses. Once the analyses to be performed are determined, E & E's SOP on sample packaging and shipping should be consulted to determine the above parameters. This must be completed prior to field sampling.

Once the samples have been collected, the following procedure should be followed:

- Transfer the sample(s) into suitable and labeled sample containers;
- Preserve the sample, if appropriate;
- Cap and put a custody seal on the container, package appropriately, and place in an iced cooler if required;
- Record all pertinent data in the field logbook and on a field data sheet;
- Complete chain-of-custody record and sample analysis request form;
- Attach custody seals to cooler prior to shipment; and



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- Decontaminate all sampling equipment prior to the collection of additional samples.

9. Calculations

This procedure does not involve specific calculations.

10. Quality Assurance

There are no specific quality assurance (QA) activities that apply to the implementation of these procedures. However, the following general QA procedures apply:

- All data must be documented on field data sheets or within field or site log-books;
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling or operation and must be documented; and
- All deliverables will receive a peer review prior to release.

11. Data Validation

The data generated will be reviewed according to the QA considerations listed in Section 9.

12. References

U.S. Environmental Protection Agency, 1991, *Compendium of ERT Surface Water and Sediment Sampling Procedures*, Interim Final, OSWER Directive 9360.4-03.

_____, 1984, *Characterization of Hazardous Waste Sites - A Methods Manual: Volume II, Available Sampling Methods*, (2nd ed.), EPA/600/4-84-076.



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U.S. Geological Survey, 1977, *National Handbook on Recommended Methods for Water Data Acquisition*, Office of Water Data Coordination, Reston, Virginia.



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1. Introduction

This Standard Operating Procedure (SOP) describes procedures for **collection and preparation of soil and sediment volatile organic compound (VOC) samples** according to EPA SW-846 Method 5035. This SOP **MUST** be confirmed and discussed with the appropriate regulatory agencies prior to sample collection, to verify that it has been accepted by the reviewing agency. This SOP must be used in combination with an appropriate analytical method (e.g., SW-846 Method 8260 [GC/MS] or SW-846 Method 8021 [GC]).

2. Scope

Included in this SOP are three (3) optional procedures for collecting samples, quality assurance measures, and proper documentation of sampling activities. In the first option, an En Core™ sampler serves as both a sampling device and sample storage unit. In the second two options, a modified syringe barrel is used to collect the sample with subsequent preserved sample storage in glass vials.

3. Method Summary

This sampling procedure is based on the United States Environmental Protection Agency (EPA), “Test Methods for Evaluating Solid Waste,” December 1996, Updates I, II, IIA, IIB, and III, Third Edition, (SW-846) Method 5035 “Closed-system Purge-and-Trap and Extraction for Volatile Organics in Soil and Waste samples.” This method was promulgated on June 13, 1997, replacing soil and sediment analysis via EPA SW-846 Method 5030A, and became effective January 1, 1998. This method is designed to minimize the loss of volatile organic compounds (VOCs) in soil and sediment samples.

This SOP applies only to collection of the VOC fraction of a sample. Soil and sediment should be sampled according to the applicable E & E SOP for each specific sample matrix.

Samples will be collected with the En Core™ sampler (or equivalent) or as preserved low and/or high concentration aliquots and sent to the project analytical laboratory for analysis:

1. Soils may be collected and stored in an En Core™ (or equivalent) sampler (low [0.5 to 200 µg/kg] or high [>200 µg/kg] concentration);
2. Soils may be collected and stored in water with sodium bisulfate preservative (low concentration only);

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3. Soils may be collected and stored in methanol (MeOH; high concentration only); or
4. Soils may be collected in some combination of the above options.

When in doubt as to the concentration of VOCs in a sample, collect both low and high concentration samples (i.e., collect multiple En Core™ samples or collect both water/bisulfate and methanol samples).

For samples collected using an En Core™ sampler, the laboratory will prepare the samples for analysis. Low and high concentration preserved samples should be collected in sealed sample vials with preservation solutions prepared by the project laboratory and then transported into the field. However, directions are included for preparation of both low and high concentration preservation sample vials in the field.

All field equipment should be cleaned with pesticide-grade methanol and carbon-free distilled water prior to use and then stored to limit contamination. Decontamination procedures are outlined in E & E's *Equipment Decontamination SOP*.

Individual VOC sample collection devices will be dedicated and no decontamination procedures should be required.

4. Sample Preservation, Containers, Handling, and Storage

Soil and sediment samples collected with the En Core™ system do not require chemical preservation in the field. Chemical preservation, if required, of the samples will be done in the project analytical laboratory after receipt from the field.

Low concentration vial samples require a sodium bisulfate (NaHSO_4) preservation solution. This solution slightly acidifies the sample and reduces the amount of biological activity in the sample.

High concentration vial samples are preserved with methanol. Methanol acts as both a preservative and extraction solution.

For samples collected by the En Core™ sample system (either low or high concentration), the holding time is 48 hours from time of collection. The preserved low and high concentration samples have a holding time of 14 days from date of collection.

Sample containers are laboratory specific. Container size, type, and style vary by laboratory. Field personnel/site managers must ensure that the containers used for sample collection match project laboratory requirements.

The field team must request sample containers from the project laboratory before the sampling event. Project laboratory supplied vials should be labeled and include the vial plus preservative weights to the nearest 0.01 g. Low and high concentration vial samples must be weighed in the field and again at the laboratory to verify shipment did not affect sample weight.

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Soil and sediment samples should be handled and stored according to standard techniques as detailed in this SOP, the project work/sampling plans, and program/project quality assurance plans.

5. Potential Problems

Potential problems with soil and sediment sampling include cross-contamination of samples and improper sample collection. Cross-contamination problems may be eliminated or minimized through use of dedicated sampling equipment and vials. Improper sample collection can involve use of contaminated equipment and misuse of sampling equipment. Proper training and care in execution of this procedure should minimize this problem.

6. Equipment

The following is a list of equipment and supplies typically used for soil and sediment VOC sample collection (please refer to the appropriate E & E SOP for other equipment or supplies needed on a project basis):

1. Logbook;
2. Analytical balance (range 0 to 100 grams [g]) and calibration weights (capable of weighing to ± 0.01 g);
3. Weighing dishes (disposable);
4. En Core™ samplers;
5. Sample vials (as supplied or designated by the project laboratory);
6. Plastic disposable syringes, 5 milliliter (ml) (the barrel outside diameter [o.d.] should be less than the sample vial neck inside diameter [i.d.]);
7. Cutting tool (for syringes);
8. Sealable plastic bags for En Core™ samplers, vials, and/or jars;
9. Waterproof ink pen;
10. Chain-of-Custody forms;
11. Shipping coolers and double-bagged ice;
12. Magnetic stir bars (able to fit and spin in the bottom of sample vial);
13. Sample Tags for En Core™ samplers;
14. Disposable gloves (powder-free);
15. Safety glasses;
16. 40 ml VOC vials or 2-4 ounce Teflon-lined, septa lid jars; and
17. Vial, jar, bag labels.



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7. Reagents

The following is a list of required reagents for VOC sample collection:

1. Sodium bisulfate (NaHSO_4), reagent grade (vial samples only);
2. Methanol, pesticide grade (vial samples only);
3. Organic-free water (vial samples only); and
4. Pre-cleaned sea sand, purified grade (both En Core™ and vial samples).

8. Procedures

8.1 Office Preparation

1. Prepare a sampling, quality assurance, and health and safety plan in accordance with contract requirements.
2. Determine how the samples will be sampled and shipped. Keep in mind the En Core™ sampling technique has a 48 hour holding time between sampling and analysis or sampling and subsequent preservation.
3. Contact project laboratory and determine in advance the most suitable sampling procedure to use (refer to Section 8.2). Verify that the project laboratory can meet the 48-hour holding time criteria for the En Core™ sampler. If the laboratory cannot guarantee that holding times will be met, collect and preserve samples in the field using the optional techniques described in this SOP.
4. Order sampling equipment.
5. Order supplies from the laboratory.

If the laboratory does not provide pre-weighed vials, or the sampling team runs out of vials, the sampling team can prepare sample vials for low and high concentration sample collection as follows:

1. Low concentration sample vial preparation:
 - a. Add a precleaned magnetic stirring bar to a clean sample vial.
 - b. Add approximately 1 g of sodium bisulfate to vial.
 - c. Add 5 milliliters (ml) of organic-free water to vial.
 - d. Seal vial with cap. Attach a sample label.
 - e. Weigh prepared sample vial, with a calibrated balance, to the nearest 0.01 g. Record weight on the label.
2. High concentration sample vial preparation:
 - a. Add 10.0 ml of methanol to each vial.
 - b. Seal vial with cap. Attach a sample label.

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- c. Weigh prepared sample vial, with balance, to the nearest 0.01 g. Record weight on the label.

8.2 Sample Collection

Sampling procedures for soil and sediment samples are outlined in this section. The project laboratory will receive three En Core™ sample units or four preserved sample vials (two low- and two high-concentration aliquots) for each sample. A standard 40-ml VOC vial or 2- to 4-ounce jar, will accompany each sample for determination of percent moisture.

8.2.1 En Core™ Sampler

The following procedure is used to collect a soil or sediment sample using the En Core™ sampling system:

1. The En Core™ sampler (see figure in Appendix A) consists of the sampler unit, the T-handle, and the cap.
 - a. Before collecting a sample, the sampler must be prepared for use.
 - b. Push plunger rod (on the sampler) down until small o-ring is against the base.
 - c. Depress locking lever on T-handle.
 - d. Insert plunger end of sampler into the opening of the T-handle.
 - e. Align locking pin (inside handle) and slot (on sampler).
 - f. Push and turn sampler counter-clockwise to lock pins in the slots.
 - g. Check to ensure sampler and T-handle are locked into place (unable to pull body from T-handle).
2. Verify the sampler plunger bottom is flush with sampler bottom.
3. Using T-handle, push sampler into soil or sediment.
4. The sampler is considered full, when the o-ring is visible through the viewing hole on the sampler.
5. Remove sampler from the matrix. Wipe excess soil from sampler exterior.
6. Invert and cap the sampler (while attached to T-handle) by pushing and twisting the cap over the bottom of the sampler, until the cap is seated.
7. Remove T-handle by depressing locking lever and pulling on the sampler.
8. Lock the plunger by rotating the extended plunger rod counter-clockwise until the wings of the plunger are against the tabs on the sampler.
9. Affix label and sample tag to sampler unit.
10. Bag sampler and store at $4 \pm 2^\circ \text{C}$ until analysis.
11. Collect two additional colocated samples using this procedure.
12. The T-handle must be decontaminated between sample locations.
13. Appendix A includes photographs and diagrams of En Core™ sampler handling.
14. The En Core™ sampler works best in cohesive granular materials and may not be appropriate for sample collection of some matrices (e.g., dry sands).

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8.2.2 Low Concentration Vial Samples

The following procedure is used to collect a soil or sediment sample using the low concentration preservation vial sampling option:

1. Calculate the sample volume required for sample collection:
 - a. Calibrate analytical balance daily. Check the balance with four (4) weights ranging from 1 to 50 g. Record readings against expected values in the logbook. All readings must be within ± 0.01 g of the expected value or the balance must be checked and recalibrated.
 - b. Prepare a sample corer, by removing (cutting) the tip off a 5-ml. plastic syringe.
 - c. Take a syringe (or equivalent sampling system; e.g., the En Core™ sampler), and collect approximately 3 ml (approximately 4 to 6 grams of soil) of sample. The sampler must determine, before sample collection, the exact sample volume to collect into a sample vial.
 - d. Weigh sample on a tared weighing dish by using the syringe plunger to push out the sample. If the sample weight is between 4.5 and 5.5 grams, then proceed to section C.
 - e. If sample weight is outside of the range of 4.5 to 5.5 grams, dispose of the weigh boat and sample. Adjust sample volume and recollect and reweigh a sample expected to be within the required range. Once the correct sample volume has been determined, sampling can proceed.
2. Sample Collection:
 - a. Weigh the prepared sample vial with preservation solution, stirring bar, etc. (See section 8.1). If field weight is not within ± 0.1 g of the original project laboratory or original field preparation weight, do not use the vial.
 - b. Collect calculated sample volume and add to sample vial. Wipe exterior of sample vial and cap.

Note: Soil samples that contain carbonate material may effervesce on contact with the acidic preservation solution. After capping the vial, check the sample and solution. If there is excessive effervescence, discard sample. Go to subsection 3. Any effervescence must be noted on both the chain-of-custody and the logbook.

- c. Weigh sample and sample vial. Record the weight on the sample label and in the logbook.
- d. Custody seals must not be applied directly to the vial, but may be applied to the bag closure.
- e. Store sample in a sealable plastic bag and store at $4^{\circ}\text{C} \pm 2^{\circ}$ until analysis
- f. Collect a second sample following the procedure in this section.

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3. Sample recollection for samples that effervesce excessively.
 - a. Weigh sample vial, stir bar, and cap (without the preservation solution).
 - b. Record weight on label and in logbook.
 - c. Tare the prepared sample vial.
 - d. Collect calculated sample volume (may use same sample syringe in section C).
and add to sample vial. Wipe the exterior of sample vial and cap.
 - e. Weigh sample and sample vial. Record the weight on the sample label and in the logbook.
 - f. Custody seals should not be applied directly to the vial. A custody seal can be applied to the bag closure.
 - g. Store sample in a sealable plastic bag and store at $4^{\circ}\text{C} \pm 2^{\circ}$ until analysis.
 - h. Collect a second sample following this procedure using the same syringe.

8.2.3 High-Concentration Vial Samples

The following procedure is used to collect a soil or sediment sample using the high concentration sample preservation vial option:

1. Take the same syringe used in the collection of the low concentration sample.
2. Weigh the prepared sample vial with methanol (see section 8.1.6). Record vial weight on sample label and in logbook. The weight must be within ± 0.1 g of the project laboratory weight or the vial must not be used.
3. Collect calculated sample volume (same as the low-concentration aliquot) and add to sample vial. Wipe the exterior of the sample vial and cap.
4. Weigh sample and sample vial. Record sample weight on sample label and logbook.
5. Bag sample and store at $4^{\circ}\text{C} \pm 2^{\circ}$ until analysis.
6. Custody seals should not be applied directly to the vial. A custody seal can be applied to the bag closure.
7. Collect a second sample following this procedure (not required, although recommended for remote sites).

Note: Use of the high concentration option will result in elevated detection (reporting) limits for all analytes in a sample as compared to the low concentration option.

8.2.4 Percent Moisture Aliquot

Completely fill a standard 40-ml VOC vial or 2- to 4-ounce septum sealed jar with sample for determination of percent moisture. This step may be omitted only if percent moisture is being determined on other sample aliquots AND the project laboratory has agreed to correct all VOC analyses using that data



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8.2.5 Trip and Field Blank Samples

Regardless of collection method, a trip blank sample should be prepared and shipped with every soil and sediment sample shipment. The project laboratory should provide trip blanks of precleaned sea sand in appropriate vials. Trip blanks must be prepared in the field if sample preservation vials are prepared in the field.

To collect a field blank, use precleaned sea sand (provided by the project laboratory), and follow the same sample collection procedure using the sea sand instead of soil or sediment.

8.2.6 Sample Shipment

All samples should be packaged and shipped on the day collected. Packaging and shipping should follow E & E's Sample Packaging SOP. Sodium sulfate is a corrosive for shipping. If high-concentration samples are collected in methanol, then packaging and shipping should follow E & E's *Sample Packaging for Dangerous Goods* SOP.

A positive seal between the vial and cap may be achieved by placing a small, wide rubber band over the cap and glass.

9. Quality Assurance

9.1 Sample Documentation

All soil and sediment VOC samples shall be labeled in accordance with standard labeling techniques and project-specific and SOP-specific requirements. The sample label should be completed to the fullest extent possible, prior to sample collection, and should contain the following minimum information.

1. Site name or identification,
2. Sample location or identification,
3. Date and time sample was collected,
4. VOC analysis requested,
5. Weight of vial (solution, stir bar, and label),
6. Weight of vial plus sample, and
7. Weight of sample.

9.2 Logbooks

A bound logbook will be maintained by field personal to record VOC sampling activities in accordance with E & E's *Field Activities Logbook* SOP. A separate entry will be made for



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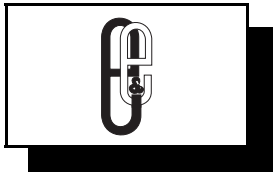
each sample collected. The logbook should contain sample identification, date and time of sample collection, weight of vials, weight of samples, and other sample observations.

9.3 Quality Assurance/Quality Control Samples

Quality assurance/quality control samples should be collected according to the site quality assurance project plan (QAPjP). The field team should collect a set of triplicate samples for both the matrix spike (MS) and matrix spike duplicate (MSD) samples. Both trip and field blanks are discussed above.

10. References

United States Environmental Protection Agency (EPA), December 1996, *Test Methods for Evaluating Solid Waste*, Third Edition Updates I, II, IIA, IIB, and III, Method 5035, Closed-system Purge-and Trap and Extraction for Volatile Organics in Soil and Waste Samples, SW-846.



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Appendix A

The En Core™ Sampler

(Source: En Novative Technologies, Green Bay, Wisconsin)

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Disposable En Core™ Sampler

**En Novative Technologies, Inc.**

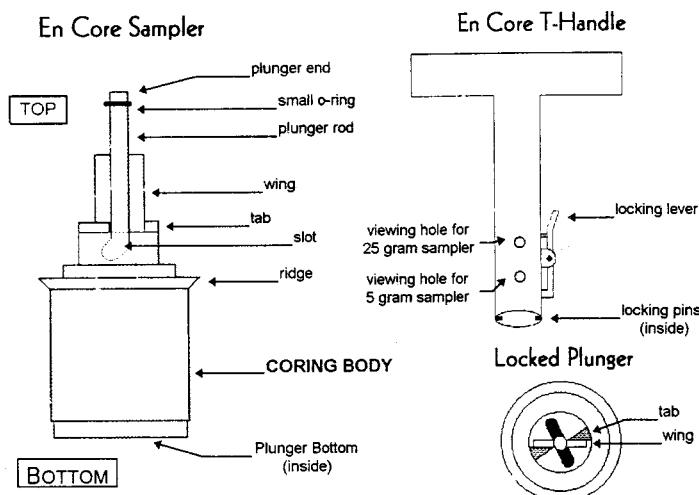
1241 Bellevue Street
Green Bay, WI 54302
Telephone: 920-465-3960 • Toll Free: 1-888-411-0757
Fax: 920-465-3963

NOTE:

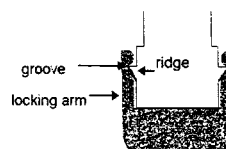
1. *En Core Sampler is a SINGLE USE device. It cannot be cleaned and/or reused.*
2. *En Core Sampler is designed to store soil. Do not use En Core Sampler to store solvent or free product!*
3. *En Core Sampler must be used with En Core™ T-Handle and/or En Core™ Extrusion Tool exclusively. (These items are sold separately.)*

SAMPLING PROCEDURES

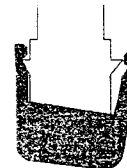
USING THE En Core™ T-HANDLE

**Sampler Correctly Capped**

(Locking Arm Grooves Seated Over Coring Body Ridge)

**Sampler Incorrectly Capped**

Cap Appears Crooked, Locking Arm Grooves Not Fully Seated Over Coring Body Ridge

**BEFORE TAKING SAMPLE:**

1. Hold **coring body** and push **plunger rod** down until **small o-ring** rests against **tabs**. This will assure that plunger moves freely.
2. Depress **locking lever** on En Core T-Handle. Place coring body, **plunger end** first, into open end of T-Handle, *aligning the (2) slots on the coring body with the (2) locking pins in the T-Handle*. Twist coring body clockwise to lock pins in slots. Check to ensure Sampler is locked in place. Sampler is ready for use.

TAKING SAMPLE:

3. Turn T-Handle with T-up and coring body down. This positions plunger bottom flush with bottom of coring body (ensure that plunger bottom is in position). Using T-Handle, push Sampler into soil until coring body is completely full. When full, small o-ring will be centered in T-Handle **viewing hole**. Remove Sampler from soil. Wipe excess soil from coring body exterior.

4. Cap coring body while it is still on T-handle. *Push and twist* cap over bottom until **grooves on locking arms** seat over **ridge** on coring body. CAP MUST BE SEATED TO SEAL SAMPLER (see diagram).

PREPARING SAMPLER FOR SHIPMENT:

5. Remove the capped Sampler by depressing locking lever on T-Handle while twisting and pulling Sampler from T-Handle.
6. Lock plunger by rotating extended plunger rod fully counter-clockwise until **wings** rest firmly against **tabs** (see plunger diagram).
7. Attach completed circular label (from En Core Sampler bag) to cap on coring body.
8. Return full En Core Sampler to zipper bag. Seal bag and put on ice.

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Using the En Core™ sampler to collect soil samples for VOC analysis (EPA Method 5035)



1. Remove sampler from sealed foil package



2. Insert sampler in T-handle, turn, and allow locking arm to click into place.



3. Place sampler over soil sample location. Note that view hole is open.



4. Push down until you can see gasket in view hole. Twist sampler and remove from surrounding soil.



5. Check to ensure that sampler is full. Place cap over sample and lock into place.



6. Release locking arm and remove sampler from T-handle.



7. Label with sticker found on foil pouch.



8. Return to foil pouch and seal. Place on ice in cooler



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STANDARD OPERATING PROCEDURE

WELL DEVELOPMENT

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1. Introduction

The purpose of monitoring well development is to ensure removal of fine materials from the pore spaces in the vicinity of the screen; to attain maximum specific capacity and better yield; and to reduce collection of sediment in water quality samples. This allows free flow of water from the formation into the well, compensates for damage done to the formation during drilling, and reduces the turbidity of the water during sampling events. A properly developed monitoring well will then provide a water sample representative of the natural groundwater.

2. Scope and Application

The most common well development methods are bailing, mechanical surging, air surging, jetting, and overpumping. All types of drilling operations alter the hydraulic characteristics of formation material in the vicinity of the borehole. Development is an essential task in the proper completion of every water well. The techniques are applicable for all types of aquifer materials, from unconsolidated sediments to fractured bedrock.

Development of a well should occur as soon as practical after installation, but not sooner than 24 hours after grouting is completed. Care should be taken not to develop any wells sooner than is allowed by the applicable state and federal regulations. The appropriate well development method (i.e., bailing, overpumping, jetting, air surging, or mechanical surging) should be selected to accommodate site conditions and project requirements. Continue until the developed water is free of sediments, or until the turbidity has stabilized at a level considered natural by the on-site geologist. In addition, development should be continued until pH, temperature, and specific conductivity values have stabilized at values considered by the on-site geologist to be typical for the site conditions. Containerize all discharge water from known or suspected contaminated areas. (Treatment may be an acceptable alternative.) Record final measurements in the logbook. Decontaminate equipment as appropriate prior to use in the next well.

3. Development Methods

3.1 Bailing

In bailing, a bottom-filling bailer (e.g., polyvinyl chloride [PVC], teflon, stainless-steel, etc.) is used to remove water from the well. Begin by tying one end of a nylon rope (typically 1/4-inch thickness) to the top of the bailer and lower it to the bottom of the monitoring well.



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Next, cut the rope to a length that allows the bailer to reach the bottom of the well while providing approximately 3 extra feet of rope. Cut the rope off at the appropriate length and tie the end to the protective casing of the monitoring well. The bailer is then allowed to fall freely down the well until it impacts the surface of the water. The impact of the bailer produces an outward surge of water through the well screen and filter pack. As the bailer fills, the flow of water reverses and fine particulates migrate into the well and are brought to the surface in the bailer. A series of short rapid strokes with the bailer at the bottom of the well will remove any accumulated sediment.

Advantages

The advantages of bailing include the following:

- No new fluids or air are introduced into the aquifer;
- Fluids introduced during drilling are removed;
- Sediment/fine particulates are removed from the well; and
- Equipment used is relatively inexpensive, easily obtainable, and, if dedicated to the well, can be used for purging and sampling the same well several times.

Disadvantages

The disadvantages of bailing are:

- It is time-consuming and physically demanding if done manually; and
- It is not effective in unproductive wells.

3.2 Overpumping

In overpumping, the well is pumped at a rate that substantially exceeds the ability of the formation to deliver water. Typically, in shallow wells (30 feet deep or less), a centrifugal or other rig-mounted pump is used; for deeper wells (greater than 30 feet deep), in which the water level is expected to drop below 28 feet below ground surface (BGS) during pumping, a submersible pump should be used. Backwashing is often used in conjunction with overpumping. If the pump does not have a backflow prevention valve, alternately starting and stopping the pump creates a surging effect in which water is driven back into the formation during the off cycle. Alternatively, clean water can be added to the well, but only as a last resort when the well screen appears to be clogged and preventing the groundwater from entering the well. Prior to adding clean water to a well, the field crew must check the applicable regulations and receive permission from the project manager.



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Advantages

The advantages of overpumping are:

- It is convenient for small wells or poor aquifers;
- Minimal time and effort are required;
- No new fluids are introduced; and
- Fluids introduced during drilling and some fine sediments are removed.

Disadvantages

The disadvantages of overpumping are:

- Does not develop maximum efficiency in a well because it does not effectively remove fine-grained sediments unless combined with mechanical surging;
- Tends to cause sand to bridge in the formations (although this can be reduced by alternating pump on and pump off);
- Can result in a large volume of water to be contained and disposed of; and
- Excessive pumping rates can cause well collapse, especially in deep wells.

3.3 Mechanical Surging

Mechanical surging forces water into and out of the well screen by operating a plunger, called a surge block, which is attached to a drill rod or a wire line (see Figure 1). The surge block is lowered to the top of the well screen and operated in a pumping action with strokes typically around 3 feet and is gradually worked downward through the screened interval. The surge block can be constructed of any materials (e.g., sand-filled PVC pipe) that will not alter the water chemistry, and should be 5 feet long with an outside diameter of approximately 0.5 inch less than the well's inside diameter. Periodically, the surge block is removed and fines that have entered the well are removed by pumping or bailing.



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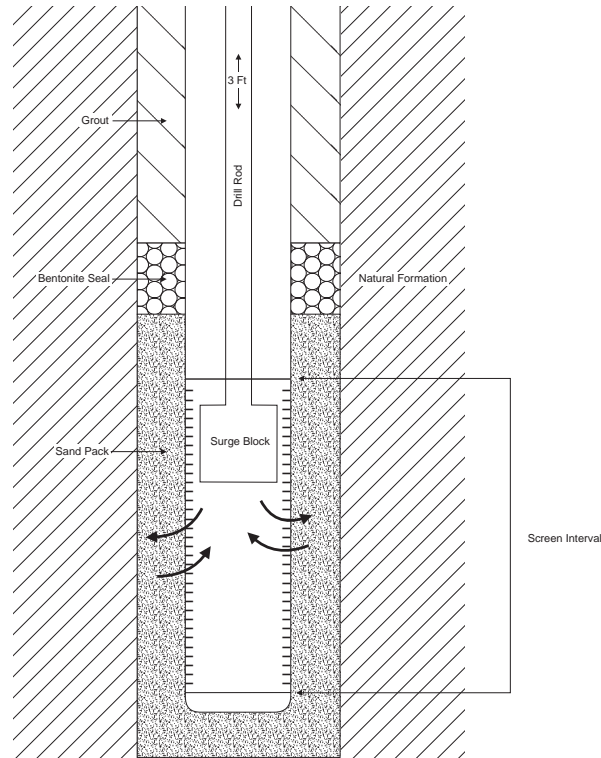


Figure 1 Mechanical Surging

Advantages

The advantages of mechanical surging include:

- Low cost,
- Effectively re-arranges filter pack,
- Has greater suction action and surging than backwashing or bailing,
- No new fluids are introduced into the well, and
- Is convenient to use with most drill rigs.



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Disadvantages

The disadvantages of mechanical surging are:

- It must be combined with pumping or bailing to remove drilling fluids and sediments;
- If screen becomes plugged with fines (clay), the well casing or screen can collapse;
- It tends to push fine-grained sediments into the filter pack;
- The well bentonite seal could be disturbed; and
- Excessive sand can result in sand-locking of the surge block within the well.

3.4 Air Surging and Air-Lift Pumping

Compressed air can be used to alternatively surge and air-lift pump a well to remove sediment. In air surging, air injected through a drill pipe lifts the water column until it reaches the top of the well casing. Then the air is shut off, causing an outward surging action in the well's screened interval. In air-lift pumping, the air flow remains on while the air continues to raise the water and sediment up and out of the well (see Figure 2).

Advantages

The advantages of air surging and air-lift pumping are:

- It is a rapid method; and
- Minimal equipment is needed (compressed air tanks or oil-free compressor, and drill pipe).

Disadvantages

The disadvantages of air-lift pumping include the following:

- Air can become entrained in filter pack and reduce permeability;
- Introduction of air can change water chemistry and biology (iron bacteria) near well; and
- Mechanical surging with pumping/bailing provides better results for wells in which yield is low and drawdown is rapid.



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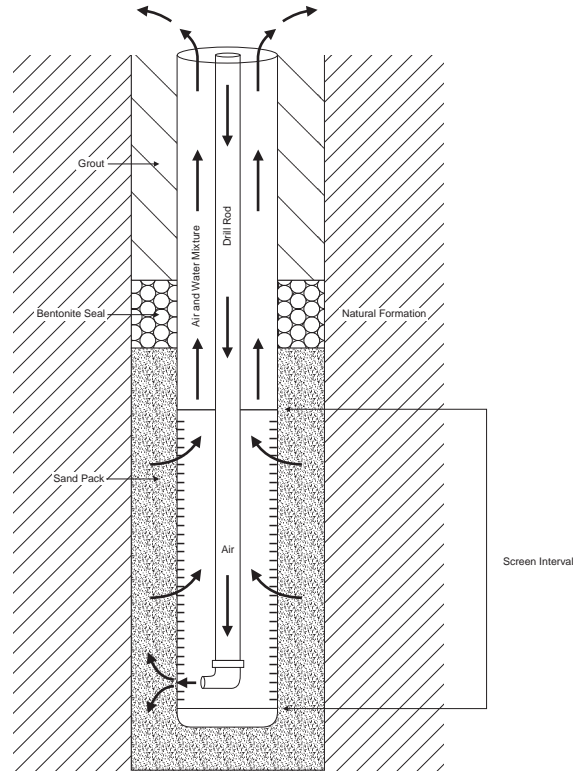


Figure 2 Air Surging and Air-Lift Pumping

High-Velocity Jetting

In high-velocity jetting, a single or multiple-nozzle device is used to direct a horizontal stream of water against the well screen. The jetting tool is placed near the bottom of the screen and slowly rotated while being pulled upward. Material that enters the screen in the backwash of the jet stream is then removed by pumping or bailing.

Advantages

The advantages of high-velocity jetting are:

- It is simple to use,
- It effectively rearranges and breaks down bridging in filter pack, and
- It effectively removes mud cake around screen.



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Disadvantages

The disadvantages of high-velocity jetting are:

- Foreign water is introduced to the aquifer;
- It does not remove drilling fluids unless combined with pumping or bailing; and
- Jetting with simultaneous pumping is not always practicable because of the limited space available within the well.

Method Summary

Well development in some form must be performed on all monitoring wells. Overpumping and bailing are the most commonly used methods of well development. These methods, combined with mechanical surging, are the most effective methods for most situations.

4. Equipment

The type of equipment used for well development depends on the characteristics of the well (e.g., casing and screen diameters, total depth) and of the aquifer (e.g., expected yield and turbidity of the formation). For example, most rig-mounted pumps and centrifugal pumps can only lift water a maximum of 28 feet. Therefore, if the well's static water level (water table) is greater than 28 feet BGS, or the water level is expected to be drawn down quickly below 28 feet BGS by the pump, then an alternative method must be used (e.g., submersible pump, bailer).

In general, the well should be developed with the drilling equipment shortly after it is drilled. Most drilling companies have air compressors, centrifugal pumps, or submersible pumps that may be used for the development process. Section 3 details the equipment necessary for each well development technique.

5. Reagents

No chemical reagents are used in this procedure. If decontamination at a well is required, see E & E's standard operating procedures (SOPs) for personnel (H&S 5.2) and equipment decontamination (ENV 3.15).



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6. Procedures

6.1 Preparation

1. Coordinate site access and obtain keys to monitor well cap locks.
2. Obtain information on each well to be developed (e.g., drilling method, well diameter, depth, screened interval, anticipated contaminants, etc.).
3. Obtain water level indicator materials for decontamination, pH, temperature and electrical conductivity meters, and a watch.
4. Assemble containers (e.g., 55-gallon drums) for temporary storage of water produced during well development. Containers must be structurally sound, compatible with anticipated contaminants, and field-manageable. The use of truck-mounted tanks may be necessary in some cases; alternatively, a portable water-treatment unit (i.e., activated carbon) may be used to decontaminate the development water.

6.2 Operation

The development should be performed as soon as is practical after the well is installed, but no sooner than 24 hours after grouting is completed. Dispersing agents, acids, or disinfectants **should not** be used to enhance development of the well.

1. Assemble necessary equipment on a plastic sheet around the well.
2. Record pertinent information (e.g., personnel, date, time, location identification, etc.) in the field logbook.
3. Open monitoring well and take air monitoring reading at the top of casing and in the breathing zone, as appropriate, and record in logbook.
4. Measure depth to water and the total depth of the monitoring well, and calculate the volume of water in the well.
5. Note the initial color, clarity, and odor of the water. Measure the initial pH, temperature, and specific conductivity of the water and record them in the logbook.
6. Develop the well until the water is free of sediments, and until pH, temperature, and conductivity have stabilized. Note the final color, clarity, and odor of the water.



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7. All water produced by development in contaminated or suspected contaminated areas must be containerized or treated. Each container must be clearly labeled with the location identification, including site name, date, and monitoring well number. Determination of the appropriate disposal method will be based on the first round of analytical results from each well.
8. No water shall be added to the well to assist development without prior approval by the site geologist. If a well cannot be cleaned of mud to produce formation water (i.e., if the yield is insufficient), small amounts of potable water may be introduced. This may be accomplished by dumping buckets of water down the well. It is essential that at least five times the amount of water injected must be produced back from the well to ensure that all injected water is removed from the formation. When most of the bentonite is out, continue development with formation water only.
9. Measure the final pH, temperature, and specific conductance of the water and record them in the field logbook.

The following data shall be recorded in the field logbook:

- Site name and location,
- Well designation (location identification),
- Date(s) and time of well development,
- Static water level before and after development,
- Quantity of water removed, and time of removal,
- Type and size or capacity of pump and bailer used,
- Description of well development techniques used, and
- Storage location of development water.

6.3 Postoperation

1. Decontaminate all equipment.
2. Store containers of water produced during development in a safe and secure area.
3. After the first round of analytical results has been received, determine and implement the appropriate water disposal method.



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7. Calculations

There are no calculations necessary to implement these procedures. However, if it is necessary to calculate the volume of the well, use the following equation:

$$\text{Well volume} = \pi r^2 T (0.163)$$

where:

r = radius of monitoring well (in inches)

T = height of water column determined from subtracting the depth of water from the total depth of the well measured from same reference point (in feet).

Because 7.48 gallons of water occupies 1 cubic foot (ft³), the following figures indicate the volume of water (in gallons) per 1 foot of depth:

Well diameter (inches)	2	3	4	5
Volume (gal/ft)	0.1632	0.3672	0.6528	1.4688

8. Quality Assurance

There are no specific quality assurance (QA) activities that apply to the implementation of these procedures. However, the following general QA procedures apply:

1. All data must be documented on standard chain-of-custody forms, field data sheets, and field/site logbooks.
2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling or operation, and they must be documented.
3. All deliverables will receive peer review prior to release.



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9. Data Validation

The data generated will be reviewed according to the QA considerations listed in Section 10.

10. Health and Safety Considerations

Depending on the site-specific contaminants, various protective programs must be implemented prior to pumping or taking water level measurements at any well. The site Health and Safety Plan (HASP) should be reviewed with specific emphasis placed on the protection program planned for well-sampling tasks. Standard safe-operating practices, such as minimizing contact with potential contaminants in both the vapor phase and liquid matrix through the use of the respirators and disposable clothing, should be followed.

Depending on the type of contaminant expected or determined in previous sampling efforts, use appropriate safe work practices.

Particulate of Metal Contaminants

1. Avoid skin contact with, and incidental ingestion of, purge water.
2. Use protective gloves and splash protection.

Volatile Organic Contaminants

1. Avoid breathing constituents venting from the well.
2. Presurvey the well headspace with a photoionization detector (Model HNU 101) or organic vapor analyzer (OVA) (Model OVA 128) prior to taking water level measurements.
3. If monitoring results indicate organic constituents, sampling activities may be conducted in Level C protection. At a minimum, skin protection will be afforded by disposable protective clothing.



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11. References

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